RATIONAL THOUGHT AS A PRODUCT OF NATURAL SELECTION

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Introduction: Rational thought and natural selection

Neil Spurway's presentation coincides with the general line of the seminar. When he was asked about the origin and nature of reason, in his answers he assumed the point of view of the school known as Evolutionary Epistemology (EE). In some ways, perhaps with the only exception of Gregor Nickel, the contributions of the speakers at the different meetings, and the comments and written contributions by the rest of participants, have always agreed that the origin and nature of reason should be explained in the framework of the evolutionary process. That is, reason is the response to an evolutionary requirement; in other words, if evolution is «evolution towards the consolidation of life» (towards the optimal adaptation to the environment in order to survive), then the «logical evolution» has given rise to reason as a good tool for the survival of the human species. This general idea has been proposed by many thinkers throughout history, but there is no doubt that the formulation of Darwin has had a special importance. Darwinian natural selection is a natural mechanism that explains how simple changes or mutations in each species are kept and why others are not. It is a process of selection of adaptive advantages «that explains the transition from one species to another and the path, slowly but surely, towards a greater perfection». Spurway has defended the adequacy and rigor of the classical Darwinian framework to explain all those traits – biochemical, morphological and behavioral traits – which appeared in different species, each under its own biological design. The same must be said of man: the animal mind and the human mind with their functions have been evolutionarily originated under the Darwinian logic of natural selection; their nature must be understood as an operational exercise of the powers that have emerged through selective evolution. Reason is thus the product of natural selection in humans: the ability to use concepts, to analyze them and relate them, to move from one concept to others, to do problem solving, etc., has been consolidated in the human mind. The cause is that, with the emergence of mutations that have made possible the increasingly complex use of concepts, evolution has been creating adaptive advantages. These have given the human species better chances to survive. We can also say that all products of reason, in one way or another, have contributed to improving the human species and, therefore, they have played an adaptive function.

Although other contributions to the seminar have not made such an explicit and fundamental mention of the Darwinian logic with the intensity Spurway has used, we believe that Darwinism is in the basic foundation of their contributions. Thus, Roberto Poli, explaining life from systems theory, says that evolution has made systems analysis an instrument of survival advantage from primordial life to the human mind. Therefore, the evolution of life made possible to build «anticipatory systems» in living beings. The same must be said of Harald Walach's ideas, since the construction of holistic sensory systems gave man a holistic perception of the space and of himself as subject. They are adaptive advantages that the organisms have probably built using the hardware or physical support of quantum mechanics. Nickel only seemed to object to the possibility of an evolutionary explanation of the mathematical operation of the mind, capable of creating the formal sciences. Manuel Curado made also an epistemological analysis of reason's frailty and sureness. He has contributed ultimately with an evolutionary explanation for the origin of properties of natural reason that we note in the troubled exercise of our rational minds. Francisco Mora and Camilo José Cela Conde also expressed strongly their commitment to science in Darwinism, but they made no explicit mention of the school of Evolutionary Epistemology. Spurway's contribution completes the explanation of reason intended by the seminar in a clear line of Darwinian evolution: evolution has produced the emergence of reason because it has been an advantage in order to improve life and its adaptation to the environment.

I. NEIL SPURWAY'S FRAMEWORK PAPER: EXPLORING THE IDEA THAT RATIONAL THOUGHT IS A PRODUCT OF NATURAL SELECTION

Biology as a starting point

I take our purpose in this seminar series as being to focus on the cognitive sciences (broadly defined) and on philosophy, not on theology. So my paper today will scarcely mention theology, though the things I have written about it in earlier articles may well come up in discussions – perhaps not this evening but certainly tomorrow.

In previous writings I have noted that Descartes' attempt to identify an unchallengeable baseline for his world view *(Cogito, ergo sum)* is now unfashionable. Yet there is no other agreed foundation – no 'first philosophy' to which all rational beings may be expected to assent. Indeed many recent thinkers have instead striven to be 'nonfoundationalist', and treat every problem in its own historical, societal or disciplinary terms. That way, however, cannot lead to consistency even within one person's mind; consensus extending over large groups will be quite impossible on any question except the impossibility of consensus.

If we are to do better than this we must agree upon a starting point for any particular chain of argument – a position which will serve as our foundation, for this particular thought-experiment. Having myself spent my professional lifetime in biological science, I am happiest to adopt a Darwinian perspective as such a starting point. Following Charles Darwin himself, many subsequent thinkers have done the same. Herbert Spencer, Georg Simmel, William James, Konrad Lorenz, Gerhard Vollmer, Michael Ruse, Daniel Dennett and Henry Plotkin are examples; and so, in a rather different way, are Karl Popper, Stephen Toulmin, Donald Campbell and Peter Munz. The general position to which all these thinkers contributed became known in the 1970s as Evolutionary Epistemology (EE, for short!). EE is the attempt to work out the implications of evolution for knowledge itself, and this is my endeavour too.

If we accept that, at least at the level of immediate causes ('material' and 'efficient' causes, in Aristotle's terms), human beings are as totally the products of evolution as any other living forms, we have to accept that not only our bodies in all their features – including sensory and nervous systems – but our *mental functions* also, are wholly the products of natural selection on the surface of this earth.

To underline this, before we go further, let me quote from Nicholas Humphrey's book on the role of consciousness, *The Inner Eye* (1986):

> «Darwin's theory of organic evolution gave me a way of looking at the living world that I could not put away. Everything in nature can potentially be explained in Darwinian terms. Whenever we find anything in nature that is beautiful, well-formed, apparently designed for a purpose, we can guess that behind it lies the slow, halting process of natural selection. The shapes, the forms, the faculties of plants and animals have evolved only because they contribute in some way to biological survival. It is as true for the shape of the trees in the forest, as for the colours of a butterfly and for the hair on our own heads – and it ought to be true for our own minds».

That is my position exactly.

Sensory and brain mechanisms

This evolutionary viewpoint provides a perspective on the limitations of our sensory and mental capacities and yet, simultaneously, an assurance that the judgements we make about the material world are reasonably reliable. Considering sensory functions first, our eyes can detect only a narrow range of the electromagnetic spectrum, yet it is a range to which most material objects which we might wish either to avoid or grasp are opaque, while the media in which they exist are not, so we can see the objects; our visual systems can operate over a brightness range greater than 10^{12}; and when maximally dark-adapted our vision reaches the ultimate physical limit, one photon at the optimum wavelength being sufficient to excite a rod, at least in the most sensitive regions of our retinas (Hecht, Shlaer & Pirenne, 1942). Yet there is a further subtlety which underlines the

evolutionary honing: a single rod, in that state of peak sensitivity, can too easily discharge by thermal accident, or under the impact of a blood cell in an adjacent capillary, so in fact we only notice a momentary flash if five to seven neighbouring rods fire almost simultaneously – the number and collecting-time being within the optimum range indicated by information theory. But this remains a quite extraordinary sensitivity. If the energy released by an average coffee bean in falling one inch (two to three cm) could be transformed wholly into photons absorbed by the collective retinas, there would be enough to give a sensation of light to all the men, women and children who have ever lived, 'and probably their tame cats and owls thrown in for good measure' (Mommaerts, 1997, after Pirenne).

For hearing there is no absolute physical limit comparable to the photon, but we can hear sounds sufficient to vibrate our ear-drums only $1/10^{th}$ the diameter of a hydrogen atom. As the integrated effect of billions of molecular impacts on either side of the tympanic membrane, this is an exquisite sensitivity – yet, most tellingly, it has evolved to apply only in a frequency-range just above those of body noises, which otherwise would deafen us (von Békésy, 1962).

On the other hand, compared to us predatory birds which hunt from many meters above the ground have higher visual acuity (that is spatial discrimination, an entirely different property from the preceding paragraph's brightness threshold); many animals can hear higher frequencies; our touch and smell capacities fall far short of those in other species to which these sensory modes matter more; and we have no capacity to detect electrical signals as some fish do, the polarization of light like some insects, and so on. (Some 80 years ago, von Uexküll designated the contrasting sensory worlds of the various species as their respective *Umwelten,* and that concept is in no way outmoded.)

Just as significantly, there is a huge range of incident energies, all potential sources of information, which no species can access – an obvious example being almost all of the electromagnetic spectrum other than what we are pleased to call 'light'. Usually in these cases the psycho-physicist can see that the bodily dimensions of animals, or the materials of which they can be made, preclude the wider range. 'X-ray eyes', for instance, could never actually occur. There also remains the very considerable possibility that there are potential information-sources of whose existence we have no idea. Nonetheless, even the inter-species comparisons which we can make show that each one could, in principle, have wider awareness than it does. What determines the capacities a species in fact possesses? – The evolutionary cost/benefit ratio.

> «We have developed 'organs' only for those aspects of reality of which, in the interests of survival, it was imperative for our species to take account» (Lorenz, 1977).

Similar arguments apply to brains. Much of the detail is highly technical, but some points are easily understood. For instance, in human beings, the areas of the sensory cortex devoted to thumb and finger tips, and to lips, are much larger than those to limbs and trunk – the relevant factor being the importance of tactile discrimination in the respective body parts, not their own surface area. And the

touch-receptors of a pig's snout project to a brain-region several times larger still (Adrian, 1947)! There are countless similar examples, leading to the fact that the ratio of overall brain volume to body volume (termed the Encephalisation Quotient) can be taken as a rough indication of the role of brain function in the life of the species – what we crudely call its 'intelligence'.

An interesting detail is that the mechanisms determining innervation density and neurone numbers are not entirely genetic. A foetus at about three-quarter term has far more nerve synapses (sensory and motor) than it will have a year or two later: extensive perinatal elimination of less useful synapses occurs in parallel with reinforcement of others. And nerve cells adjust their volume largely in proportion to the number of their active synapses, even to the extent of disappearing altogether if they aren't doing anything. This process has been widely observed in the peripheral nervous system, and undoubtedly occurs in spinal cord and brain too (Edelman, 1989). An extreme instance is seen in the fact that a child blind from birth has more brain volume devoted to touch, smell and hearing and much less to vision than its sighted sibling. On the output side of the nervous system, the side which controls activity rather than subserving sensation, exactly analogous mechanisms apply. Selective shaping of the nervous system by the environment and the organism's requirements is accomplished very rapidly compared with the geological time scale of the genome's evolution. «*The Darwinism of synapses replaces the Darwinism of genes*» (Changeux, 1985) and occurs much faster. Yet it is still Darwinism: development of the most useful, elimination of what is insufficiently useful – a process of natural selection.

Whether the mechanism of selection is genetic or neural, we may conclude that both the information captured and the data-processing capacity applied to it are biologically determined by their cost/benefit ratio. Looking back to the previous quotation from Konrad Lorenz (that 'organs' have developed for the aspects of reality of which it is essential that we take account), not just our physical but our mental 'organs' – our capacities to undertake particular forms of thought and formulate particular kinds of concept – have been selected by their contributions to our ancestors' survival and reproduction. And so have our capacities to effect particular kinds of response.

Adaptation for survival

The fundamental driving force behind this fact was put 'crudely but graphically' by Simpson (1963):

> «The monkey who did not have a realistic perception of the tree branch he jumped for was soon a dead monkey – and therefore did not become one of our ancestors».

It is no longer thought that monkeys, *sensu strictu*, are direct evolutionary precursors of human beings, but Simpson's comment can be read with no loss of impact in terms of the common precursor of *Homo sapiens* and modern

monkeys. Furthermore, what is true of spatial and other physical judgements must, from a Darwinian standpoint, be true of biological and social judgements also. The consequences of being wrong would in many cases have been fatal, and in all others they would have been failure to thrive in the competitive world. But we have survived, and emerged from a network of ancestors who all survived, so our social dispositions must have been on balance valuable, over the course of history, and our objective concepts highly trustworthy.

Of course, we are not born with detailed knowledge of our individual environments, let alone individual anticipation of each of the uncountable number of events which will occur in a given life. What is conveyed in our DNA, and more finely tuned by synaptic competition, is responsiveness to particular forms of regularity in our environments. Initially, in the evolution of the species, it will have been solely the physical environment; later, increasingly the social one. An example of the first kind is that nervous systems are not predisposed to judge the leap to a particular branch, but to make spatial judgements generally. An instance of the second kind is that the brains of human infants are not adapted to the learning of German in one child and Chinese in another, but in each to the learning of *language* generally. However, the extraordinary speed with which we do learn the language(s) heard all round us in our early years must give the strongest indication to any doubter that the propensity for such learning is, indeed, inborn (Pinker, 1994). Furthermore, the fact that it is only retained at this high level over the period of life in which it has been likely, during the emergence of our species, that it would be worthwhile to maintain so much neuronal volume and adaptive capacity in the brain regions concerned, is an equally persuasive indication of evolutionary adaptation.

Simpson continued from his comment on our tree-dwelling precursor:

> «Our perceptions do give true, though not complete, representations of the outer world because that was and is biologically necessary, built into us by natural selection. If it were not so, we would not be here!».

By the same token, we may add that not only *per*ception, but also many aspects of *con*ception must be reasonably accurate. Competition searchingly tests those concepts which have direct survival consequences, though not those for which this is not the case. I have contended in previous writings that theological concepts such as those of other worlds, of events outside space-time, and of the inner structure of the deity are in that latter category – of concepts whose purported truth-content is not survival-tested, though the religious and social practices to which they lead certainly are tested. But, as I said at the outset, I don't want to go further in that direction in this paper. By contrast, concepts which do have direct survival consequences inextricably embody and imply the reality of the world perceived – we may know that world imperfectly, but we know it adequately for our survival. EE therefore gives us justification for cautious confidence in the approximate validity of our concepts of the world: *it makes sense of common sense*! Proponents of EE contend that no other philosophical stance permits such confidence.

Innate ideas – and knowledge as self-reference

In terms of the history of philosophy, it will be evident that EE represents a distinctive position in relation to the debate, extending from Plato to the present, about the existence or otherwise of innate ideas. You will all know that Empiricists, of whom probably the most extreme was John Locke, have always denied that we have such ideas – the mind of a newborn baby has been, to them, '*tabula rasa*', a clean slate. The opposite school, broadly classed as Idealists, have maintained that we perceive the world in terms of ideal concepts with which we are born. The earliest fully recorded version of *this* stance is that of Plato. But Darwin himself commented in his Notebooks:

> «Plato says in Phaedo, that our imaginary ideas arise from the pre-existence of the soul, are not derivable from experience. Read monkeys for pre-existence!».

Before this, he had already said:

> «He who understands baboon would do more towards metaphysics than Locke».

An account of innate ideas more acceptable than Plato's to the relatively modern mind was that of Kant. For him concepts such as of space and time (concepts fundamental to Newtonian physics) are given to us '*a priori*': that is to say, they are not products of our personal experience, but instead are the basics in terms of which we interpret all experience. But this has the unhappy consequence that, as we can never assess the world without these *a priori* concepts, we can never know if they are right. Nor can Kant's approach explain how such concepts arise. William James, at the start of the 20th C, and more recently and consistently Konrad Lorenz, argued that they are not mysterious, but products of Natural Selection – and consequently trustworthy: though they are almost certainly not perfectly correct (and if they were we could never know it), we do know that they are sound enough to live by:

> «In the early years of the Second World War, when by coincidence he was a professor in Königsberg [Kant's home city], Konrad Lorenz used Darwin's idea about the formative role of the past to put the finishing touches to Kant. He argued that Kant's scepticism about what the world is really like was unjustified because the cognitive structure which enables us to know what the world is like had evolved through natural selection. The reason why our minds have this particular, and no other, cognitive structure… must be that we have evolved [here] and not flown in, so to speak, from outer space. Our cognitive structure has been selected by and, therefore, reflects or represents, the real world» (Munz, 1993).

So what is inborn in the individual has arisen by the accumulated actions of natural selection upon countless generations of ancestors. In technical bio-philosophical language, such inborn concepts (or, we would now say, propensities to form concepts) are:

> «Ontogenetically *a priori,* but phylogenetically *a posteriori*» [innate in the individual but experience-based in the species] (Lorenz, 1977).

Thus:

> «The great resistance of the empiricists to innate knowledge is made irrelevant… in the form of a more encompassing empiricism» (Campbell, 1974).

A wonderful summary!

Yet this positions us to think more broadly about the nature of knowledge itself. It is an outcome of the world's effects on us, both over evolutionary time via genetic selection and over the individual life-time by means of synaptic selection and subsequent learning:

> «From the perspective of biology, knowledge… is a form of self-reference… The knower is part of the known, and has been shaped by what is known. The reflector reflects, more or less adequately, because it is itself part of what is being reflected. The biological perspective, therefore, provides an assurance that the reflector is adequate and also explains at the same time how it has been shaped by natural selection to be adequate» (Munz, 1993).

Again:

> «… the impressive order in nature is not, as has been claimed by idealistic philosophy, a product of our thinking and imagination…, on the contrary, human thought itself is a product of the emerging order in nature» (Wuketits, 1984).

Indeed, it is the extent of that order which makes possible the sweep of human reason.

A final instance of the influence of the world, by natural selection, upon our emerging minds is the inveterate human disposition towards generalization and induction. David Hume pointed out that induction can be justified only psychologically, not logically, but EE explains why we all have this psychological drive: living beings can only adapt to consistent features of the world ('*the impressive order in nature*'), but it is imperative for their survival that they do so adapt; conscious beings must therefore have the propensity to look for such consistencies.

We can say again that EE – 'Philosophical Darwinism' – has at last made sense of 'common sense'!

Exploratory knowledge

If human understanding were limited to that which could be directly passed on as innate concept-forming propensities, our species' rate of intellectual progress would be restricted to that at which DNA could mutate – either the DNA which directly affects these propensities, or that which modifies rates of synapse-change. Individuals could perhaps learn from experience, but no mechanism is evident from a Darwinian standpoint by which their learning could be *passed on* faster than the mutation rate. (The assumption that it could be directly conveyed by inheritance would be an instance of Lamarck's mistake.) Yet the most superficial

glance at the modern world shows that individuals can not only learn, but pass on their learning, at rates many orders of magnitude faster than that of mutation!

Mainstream evolutionary epistemologists, particularly those of the German-language school such as Lorenz (*loc. cit.*) and Vollmer (1984), regarded each actual concept we form on the basis of our inherited propensities as a hypothesis about the world: 'hypothetical realism' is the label given to the resultant epistemological stance. These concepts – these hypotheses – are, of course, challenged by our encounter with our surroundings and, where they prove unfruitful, either *we* shall be eliminated (if they have drastic short-term consequences) or we, as conscious beings, will eliminate *them* in favour of alternative hypotheses which we shall put, in their turn, to experiential test. With this account, we have entered the realm of cultural, as distinct from biological, evolution.

An even more eminent philosopher, Karl Popper, although only fully espousing Darwinism quite late in his intellectual life and never using the term 'hypothetical realism', took what was effectively this idea forward to form the basis of his mature philosophy of sophisticated knowledge, and particularly of science. Although asserting the consistency of knowledge-growth '*from the amoeba to Einstein*', and regularly referring to his viewpoint by the label 'EE', Popper (e.g. 1972) had little concern with the biological history, or the mechanisms, of *natural* selection. His chief interest remained, as it had always been (Popper, 1959), the process of successive '*conjectures and refutations*' by which knowledge advances in organized human societies: in short, cultural evolution. This is an aspect of the contention, sustained throughout his writing, that hypotheses can never be proved, but should instead be so stated that they make specific predictions vulnerable to challenge; their success, if these predictions are not refuted, is merely that they have for the time being evaded disproof.

Of the other authors from whom I have quoted, only Campbell *passim* and Munz, in much but not all of his writing, have had in mind this conscious level of conjecture and potential refutation when they used the term 'EE'. From Darwin, through James and Lorenz to Vollmer (and many authors between) the earlier, biological processes, affecting the unconscious propensity to form basic concepts and the selection of the better ones by preferential survival, *not* the highly-conscious formulation and frequently rapid, purely mental rejection of sophisticated ones, is what 'EE' refers to. The respective usages are not unconnected, yet their emphases are very different. Each is a valid meaning of the term 'EE', but they should not be confused. Bradie (1986) distinguished them by the labels 'EEM' and 'EET', respectively. EEM stood for evolution of cognitive Mechanisms and EET for evolution of Theories. So EEM involves DNA, EET acts through culture.

Nonetheless a final, but highly important, point must be that – according to Popper and those who follow him – it is only in respect of consciousness, and therefore speed, that the two modes of learning differ. These authors contend that in neither mode is a model of the external world *imposed on* the living entity by that world. Now the pre-conscious part of this contention is uncontroversial.

Unicellular and other very simple organisms without nervous systems do not even have body structures by which the individual could learn from experience, yet by natural selection they become increasingly adapted to the world over evolutionary time, and so may be regarded as having acquired information about it. The process is not only entirely unconscious but – if orthodox understanding of mutation is correct – entirely random; yet the result is a form of learning. Consider a bacterial species in which a mutation occurs, affecting its resistance to an antibiotic. If the mutant is more susceptible, it will die particularly quickly; but if it is more resistant it will flourish, and gradually replace the earlier strain. Such development of antibiotic resistance is clearly an instance of what Donald Campbell characterizes as *'blind variation and selective retention'*. A mindless process like this clearly does not come within the compass of epistemology, but the learning processes which *are* within that compass are generally considered by evolutionary epistemologists to be contiguous with such primitive learning. Popper and his disciples, in particular, are radically committed to such a view.

Animals with nervous or other responsive systems, to which something approaching the concept of an epistemology begins to become applicable, might more reasonably be thought to acquire information receptively, by the action of the outside world upon the individual. However, mainstream EE thinking argues that such a concept tacitly assumes that the world consists of discrete bits of information, which could be picked up by passive response or painstaking observation. Yet the world 'is not labeled' (in Gerald Edelman's phrase), and the radical evolutionary epistemologist contends that such passive information-acquisition never happens. Instead, they assert, the 'labeling' is done by the organism, imposing its comprehension-patterns on the world which it experiences. Random 'conjecture' and the risk of refutation is thus the picture of all learning in mainstream EE – slowly, through the phylogenetic elimination of less appropriate 'conjectures' among organisms without nervous or comparable systems (EEM); and much more rapidly, within the individual, where the effectiveness of a conjecture can be consciously assessed (EET). Of the animals in between, those which have responsive systems but no effective societies and no consciousness can learn as individuals but have no means of passing on their knowledge. Where there is a society, as in social insects like ants and bees, limited learning can be spread through a colony or hive but, on present understanding, not beyond, and not to a succeeding generation.

Animal learning

It is clear that we must look a little further into animal learning. I am no expert in this literature. Such reading as I have done, however (Walker, 1987; Pearce, 2008; and, for a helpful introductory outline, Villee & Dethier, 1971 and later editions), raises a further big question about the view just outlined. It is a question about the universality of trial-and-error learning. Of course this sort of learning occurs widely. Among the paradigmatic behavioural studies was that

of Thorndike (1898) on cats, learning to escape from 'problem boxes'. Each box had a series of mechanical devices – strings to pull, levers to press, etc. – and in each case operating one device (a different one in each box) would open the trap door. Though Thorndike's 15 animals varied in their energy, all began with undirected struggles, and all got much quicker at escaping from a given box once they had chanced upon the right action; in most of them this learning was impressively rapid. They also got better at finding the ways out of later boxes, even though none of the ways were the same, so that they effectively became 'more intelligent'! It would be hard to imagine a clearer instance of the Popper/Campbell '*blind variation and selective retention*', as applied to a neuronal function. Although it is exceedingly hard, if not impossible, to design an absolutely incontrovertible behavioural experiment, there are strong indications that elementary trial-and-error (or 'instrumental') learning can occur almost as far down the evolutionary tree as there are nervous systems – for instance, that earthworms can be taught to opt much more often for one branch of a Y fork (the simplest possible maze) than for the other. Nevertheless, Popper's reference to amoebae is probably best regarded as a rhetorical flourish. Single-celled animals, like *amoeba* and *paramecium*, certainly use trial and error in any given exploration, withdrawing and moving in a new direction if they encounter obstacles or unfavourable environments; but I have found no evidence that they modify subsequent instances of this behaviour on the strength of experience.

However, at the other extreme from trial-and-error is 'habituation' – the reduction of response to a repeated stimulus. A classical investigation here was Humphrey's (1933) study of snails, crawling on a board which was jerked at regular intervals. At the first jerk, a snail would draw in its horns, but repeated jerks elicited gradually decreasing responses, till a fully habituated snail would ignore the jerks completely. To describe this in Popperian terms, as random exploratory behaviour with the 'successful' response being gradually 'reinforced', would be stretching language to breaking point. If there is an ambiguity of classification, it is between 'learning to ignore' and simple response-fatigue!

The difference between the Thorndike and Humphrey accounts is not a matter of the animals' complexity. A snail's nervous system is simpler than a cat's, but we have already seen that simpler animals than snails can learn by trial and error. Conversely, habituation is the basis, not only of many conditioning studies in laboratory birds and animals, but of aversion therapies in humans. I can see no way to describe aversion therapy as an example of blind variation and selective retention.

Closely related to habituation is what must be the best-known behavioural pattern of all – Pavlovian conditioning. This can be applied in trial-and-error situations, such as maze learning, but the classic salivating dogs were simply responding to external stimuli. Yet they were indisputably learning. And such classical conditioning can be demonstrated in animals of every level of complexity – probably, in this case, including *paramecium*.

In any case, vertebrates of all phyla show instances of learning by copying. Most often the copying is of parents. Young gannets cannot eat after they have

left the nest till they have watched older birds diving for fish (Nelson, 1977), while oyster-catchers not only learn to forage on shell-fish by watching their parents, but specifically adopt from them one of two techniques for dealing with mussels. They either stab the flesh of mussels lying open in shallow water, or forage above the water level to pull closed mussels off the rocks and hammer them open; but they do neither until they have been taught, and which of the two strategies they then adopt follows that of their parents (Norton-Grifiths, 1969). Of course, there are also many mammalian instances of learning from parents. More specific to birds, though even then not wholly so, is the well-known learning of particular patterns of song, not this time from parents but from any nearby members of the same species. And specialist mimics, such as parrots and bower birds, are copying all the time.

Skills are learned by imitation. In human affairs, however, there is yet another mode of knowledge-transfer: language. It is almost incredible that such powerful talkers and fecund writers as Karl Popper and Peter Munz could have adopted a formal epistemology which appeared to deny the possibility of learning through language!

I conclude that Campbell and Munz, as well as Popper himself, were over-enthusiastic for the latter's concept of '*conjecture and refutation*'. I agree with them that this model is unassailable as the distinguishing mark of good scientific practice, but not that it is an account of all learning. In fact, I have come to feel that they weaken, not strengthen, their case by insisting on it as the keystone of EE. Learning is by experience of the world. Non-neural learning, passed on in the genome, cannot be other than by random mutation and natural selection. Learning by sensory-nervous systems is also quite often by trial and error, but we have just seen that it can alternatively be by any among several forms of direct knowledge-acquisition. Where the learning involved requires Edelman's 'labelling', this can be done *post hoc* within the learner, however the raw knowledge was acquired.

Indeed, as a development from my earlier papers, I have lately come to think that this whole concern with how knowledge is acquired has been a distracting irrelevance. What matters is not how concepts are arrived at, but how they survive. And the essential contention of EE is that only those concepts which withstand the filter of natural selection can survive. They will withstand that filter either if they are more or less right, or if their being wrong does not matter to our survival, but not if they are wrong in ways that do matter.

Let me conclude this section by stating explicitly what can hardly have failed to convey itself implicitly already: that I regard human learning, and all other brain functions, as contiguous with the homologous animal functions. Animal learning is both a precursor and a model of human learning. For the 21st C biological scientist, there can be no sharp divide. There does seem to have been a step change in respect of language, yet even that was the result of many converging factors, most of them being gradual, not step-changes, in themselves (Deacon, 1997; Mithen, 2005). I know of no evidence for any other step-change. Even as regards the ultimate topic of this seminar series, rationality, I see no

reason to think that it is a purely human capacity. It must be so, of course, if you believe that rational thought can only be conducted in words, but in my view that belief is a linguistic philosopher's self-delusion. Machiavellian tricks among chimpanzees, the conduct of an attack by lions, the use of tools by crows, all in my judgement have the hallmarks of primitive, non-verbal rationality.

Competing philosophical approaches

The core of mainstream epistemology is a search for the characteristics of justified, true belief. Such epistemology has therefore, as Bradie (2004) stresses, been less concerned to *de*scribe the processes of knowledge-acquisition and concept-formation than to *pre*scribe how these activities should be undertaken if their outcome is to be trusted. EE is equally concerned with justification, but looks to the fact of concept-survival to provide it, rather than to the method by which the concepts were arrived at. And it regards the beliefs so justified, not as ever being certainly true, but as being «*well-formed and reliable hypotheses*» (Hançil, 1999) – reliable, that is, in making our practical way in the world. Thus EE (with emphasis on Bradie's EEM) offers strong grounds, independent of traditional philosophical speculations, for believing that the world we sense is objectively real, that our fundamental concepts of it approximate usefully to that reality, and that we can gradually extend those concepts in the direction of yet better understanding by formulating our conjectures tightly enough that they can be subject to experiential test – ideally, by direct experiment (EET).

In the century or more from Darwin to Lorenz, EE was essentially the field of biologists. Despite the advocacy of William James it attracted little attention from psychologists, who in the era of Fechner, Helmholtz and Wundt were concerned principally with physiological mechanisms, and in that of Watson and Skinner were committed to Behaviourism; physiological psychologists were not interested in theoretical recourse to unobservable causes, and Behaviourism forbade such recourse as a matter of dogma (Plotkin, 2001). As to professional philosophers, till the impact of Popper, Campbell and Munz became unignorable, the overwhelming majority of professional philosophers had other concerns. In my own presumptuous overview, once the dominance of Hegel had subsided, the working-through of Positivism ('Logical' and otherwise) until its ultimate collapse by self-contradiction, occupied most attention till about the end of the 1940s. In the Anglo-Saxon world this was followed by an uninspiring focus on language use, in France by Structuralism and its successors, and in Germany by the obfuscations of Heidegger – all of which together issued into the postmodern view of truth as a mere 'social construction', and all ideas as relative. EE stands over against such futility.

Among philosophers sympathetic to the evolutionary approach, the most common challenge is reminiscent of mine, in that it also is to the radical Popper-Campbell-Munz version of EE ('EET'). A few paragraphs earlier I criticized this account's claim that no information is directly imparted to the nervous systems,

either of animals or humans, but that all learning is by the formulation of hypotheses (implicit if not explicit) and their subjection to subsequent test. The professional philosopher's commonest critique closely parallels this but falls more narrowly, *within* the sphere of human hypothesis-generation. The Popper group's contention that this process is initially completely random, albeit that a large percentage of our hypotheses are rejected as soon as we are aware of them, is designated 'Thesis Darwinism' by Rescher (1977). Philosophical critics such as he contend, as almost all practicing scientists would agree, that in fact only hypotheses which appear to have some prospect of success are ever formulated, though the subsequent selection processes are as radically refutational and Darwinian as all evolutionary epistemologists have steadfastly maintained.

> «Admittedly Campbell (*loc. cit.*) went on to acknowledge "the many processes which shortcut a more full blind-variation-and-selective-retention process", referring to them as "inductive achievements, containing wisdom about the environment achieved originally by blind variation and selective retention". This escape from the extreme randomness of the original position was not open to Popper, who famously rejected the possibility of induction. But the whole approach fails to convince me. Hypothesis-formation is a largely obscure and undoubtedly very variable process, but the notion that it is entirely random, even at its most initial stages, does not ring true: the juxtaposition of metaphors and other mental models is, I am sure, not entirely blind. Even the dream of a snake biting its tail, said to have led Kekulé to hypothesize the ring structure of aromatic hydrocarbons, was not random – deeply intuitive and sub-rational, but by no means totally random».

From knowledge to reason

In my account so far I have scarcely talked of 'reason'. This is because I have been outlining EE, largely as its previous exponents have expounded it. I have drawn attention to what I consider to be two related faults within its structure, as normally presented, but stressed that neither criticism challenges to the least degree the fundamental contention – I would rather say the fundamental insight – that the mechanism by which mental, as well as sensory and motor, capacities have been handed down to us was the natural selection of those which enhanced, or at least did not impair, our chances of surviving and flourishing in the world.. Yet I have adhered to the customary language of EE in talking essentially about 'knowledge'. I have extended this seamlessly into 'concepts', believing that concepts constitute the ways in which we store knowledge. One task of the development stage I have now reached is to amplify this relationship. Then I must move from concepts to reason. But the very first step must be to point out that I have yet to acknowledge the distinction between the learning of skills and the learning of facts – between 'knowing how' and 'knowing that'.

In my excursion into animal learning I was dealing either with innate behaviour or with skills, with 'knowledge how': how to hunt, how to sing, how to escape from a problem box. By contrast, when talking earlier of human

understanding of the physical world I spoke of concepts, such as those of space. Yet I also stressed that it is not the concepts themselves, but the behaviours to which they lead, which are the subjects of natural selection. In other words our primate ancestors' knowledge of *how* to jump to the next branch was actually what was tested. 'Knowledge that', factual knowledge, was presumably secondary, derivative from the 'how' knowledge. Of course, we cannot know how far back down the evolutionary tree (i.e. how much simpler in terms of neurological complexity) 'knowledge that' could meaningfully be distinguished. As a biologist I almost certainly envisage it as going further back in history, to simpler nervous systems, than most philosophers and theologians of earlier generations would have done, and many even now would probably do; but I suspect we might all agree that 'knowledge how' is primary, 'knowledge that' is derivative. And the Evolutionary Epistemologist, whether Lorenz or Popper, thinking of the protozoan's genetically given dispositions to turn away from an obstruction or swim up the concentration gradient of a nutrient chemical, is directly referring to propensities to act, to 'how' dispositions. The 'that' knowledge of one of the world's regularities which each disposition implies is a feature which *we* perceive, but the protozoan does not and cannot.

'Knowledge that' is thus seen as the product of abstraction and generalization from 'knowledge how' – or, at least, from some forms of knowledge how. As such, I do not think it differs sharply from a *concept*. In practice we tend to use the word 'concept' only at rather greater levels of generalization and abstraction, and at the extreme (in terms like 'the concept of mind', or 'the concept of time') this difference is very great, but at the lower end I can identify no sharp distinction. Indeed, I wonder whether *any* specific factual knowledge comes between the knowledge of how to swing among tree branches and the emergence of an incipient concept of three-dimensional geometry.

In saying these things I almost certainly risk being accused of philosophical *naïveté*, and my next claim will doubtless redouble that risk: it is that reason is the capacity for handling concepts, so that where there are concepts there is reason. In support of this sweeping proposition, I can quote at least one definition:

> «*reason*. The general human 'faculty' or capacity for truth-seeking and problem-solving, differentiated from instinct, imagination, or faith in that its results are intellectually trustworthy – even to the extent, according to rationalism, that reason is both necessary and sufficient for arriving at knowledge» (Belsey, 1995).

It should be clear, from everything I have said previously, that I do not accept that reason is *sufficient* for arriving at knowledge, let alone for formulating concepts – experience is essential too – but reason being *necessary* to their formulation is an appealing claim. For the purpose of the present paper, however, it doesn't matter if you disagree about that: we only need to agree that the propensities to acquire factual knowledge, to form concepts, and to reason about both, are all so closely intertwined that it seems impossible retrospectively to disentangle the evolution of any one from that of both the others.

Developing this stance, let me make clear that I do not regard reason as a single, megalithic property, as Enlightenment thinkers appear to have done. (They often spelled it with a capital 'R', to emphasize that point.) Still less is it, for an evolutionist, «*A spark of something close to divinity, trapped within brute beasts*», as a recent essayist (the Polish philosopher, Konrad Talmont-Kaminski, 2007) characterised the Enlightenment view.

For me, reason is an envelope term, indicating such capacities as those to extrapolate from concepts, compare them, weigh them against factual evidence, work out practical policies in the light of both factual and conceptual knowledge, and so on. Aristotle's distinctions between 'theoretical', 'practical' and 'productive' reasons cover much of this ground; in any case, they endorse the view that 'reason' is not a single, unique capacity. Quite possibly the various forms of reason developed at different rates in different groups, as we can see to this day that they do (to different rates and different extents!) in different individuals. Nevertheless, from the standpoint of an evolutionist, they have all developed because they provided adaptive advantage, they enhanced survival. For the purposes of this paper, that sufficiently justifies using one word for a set of related but not identical capacities.

A final comment in this section is that the basic concepts of space, which figured prominently in the earlier parts of this paper as vivid instances of concepts whose accuracy has high survival value, are in fact probably fundamental to our reasoning. Piaget's accounts of infants, reaching out for objects and linking touch, body geometry and vision, prepare us for such a view. And it is interesting that the British metaphysician, Hilary Lawson, comments that «the nature of space… has immediate consequences for the character of perception and experience as a whole» (2001). We may note, too, that spatial metaphors abound in every advanced language; and it is not only in everyday speech but in sophisticated physics that they are in their turn basic for our thinking about time. Without space and time, any rationality we retained would not be recognisably what we in fact mean by that term.

Practical reason

I also suggest, perhaps more controversially, that whether we start from evolution or from animal behaviour, we are also obliged to question «the tacit assumption that what cannot be reduced to logical method is non-rational» (Hooker, quoted by Talmont-Kaminski, 2007). Like me, Talmont-Kaminski seeks to take proper account of «the continuum of epistemic methods (Campbell '74) that runs from the simple chemotaxis of single-celled organisms such as the paramecium, through such everyday uses of perception as looking both ways before you cross the road, to the ever-growing family of highly specific methods used (and tested) in science… The precise path this continuum follows can be traced both in terms of the kinds of distinctions organisms are capable of making – from the identification of the slope of a sugar gradient made by a paramecium, through the human ability to

identify someone they know merely by hearing their footsteps, to the detection of a subatomic particle in a particle accelerator – as well as in terms of the kinds of models organisms use to organise their knowledge – from the models pragmatically implicit in the reactions of that paramecium, through the explicit understanding people have of their surrounds, to the purely mathematical models used when dealing with the counterintuitive nature of the quantum world».

So Talmont-Kaminski concludes that: «By considering reason in the concrete context of actual reasoning beings rather than as an abstract set of rules and relations, naturalism forces together epistemology and philosophy of mind … [to produce] the embodied, situated cognitive science that [came] of age during the last decade of the previous century… [The resulting] analysis of the role played by perception moves beyond philosophical standards that assumed the construction of a complete and neutral model of the environment, and instead learns from neurological and other empirical studies that perception is highly constructive and closely tied to action, giving us access, at the right time, to information which is adequate and in the appropriate form to make decisions that need to be made at that very point… [including the] everyday practices people apply when crossing the street or choosing fruit at a grocer's». A very similar account is developed at length by Lakoff & Johnson in their major book, *The embodied mind* (1999). Like them, Talmont-Kaminski is focusing on reason in practice, not in the textbook. It is not only continually inductive, as we noted earlier, but it is almost always «*quick and dirty*»: no way can the limited and quite slow processing capacity of a biological nervous system, deriving its policies for action from the flux of experience, afford to wait for the formal rationalities even of Aristotelian, let alone of symbolic logic. If it did wait, the cheetah on the savannah or the bus in the city street would have despatched us, long before we had even decided what we wanted to do, let alone carried the decision out.

Finally, hear the psychobiologist, Henry Plotkin (2001), not exactly on reason, but on its essential precursor, intelligence:

> «Intelligence evolved… because of the inability of the main biological programme, evolution as normally understood, to deal with significant fluctuations in the conditions of the world. It was the adaptive value of being able to track conserved, co-varying relationships in the world, which are too fine to be detected by evolution itself, that led to the evolution of [neural] learning and intelligence. Put in other terms, the evolution of intelligence constituted the partial resiting of behavioural causation away from genes and into neural networks».

If I were to add one gloss to this comment, it would be that I take 'too fine' to imply, particularly often, 'too short-term'.

Some test cases

People in previous audiences have asked me how my radical evolutionary view can explain the developments of the arts, of mathematics, of the sciences etc. In

each case, the questioner seems to have thought that it could not; in no case, however, do I see any problem. This part of my text is drawn almost directly from the pre-circulated paper, *Theological implications of evolutionary epistemology* (Spurway, 2010).

The arts

How can the arts be explained and understood, as consequences of natural selection? I make two points today…

Firstly, the skills involved – manual skills in the visual arts and instrumental music, linguistic skills in the literary arts, kinetic skills pre-eminently in dance – are easily seen as developments from skills beneficial to survival. From the skill to chip an axe would derive the skill to carve, first a simple figurine and, many millennia later, a marble statue. Similarly for the other arts. Leisure, and society's approval, would both have been necessary, and this seems to fit the archeological record: incontrovertable visual artefacts have been found only in sites dating from within the last 100,000 years, such as the Bombos Caves in South Africa (Henshilwood *et al*., 2002), when it is reasonable to think that favourable living conditions and societal organisation would have allowed time for art.

Point two is that the emotional effect of any art – painting and sculpture, music and song, acting and dance – is clearly capable of powerful influences upon both performers and audience, and the artistic expressions which flourished within a society would be those which contributed constructively to its cohesion and well-being. Nevertheless, the artistic message is emotional, not cognitive. No propositions are being uttered, no truth-claims made. There is no respect in which what are called 'artistic statements' compare with concepts of space, or of what is or is not alive. Both have powerful influences on flourishing and survival, but the influence of art has nothing to do with it's being factually correct. A challenger might argue that, where the art is highly representational in style yet does not seem to the viewer to succeed in its representation, its artistic message will be impaired; even here, though, the message itself does not consist in the representation, though it is conveyed through it.

I believe the case is exactly the same as for religion; certainly no firm borderline can be drawn between the arts and religious artefacts and rituals in primitive societies. Whether it can in advanced ones would be an interesting debate! But, as I said at the outset, I'm not going into religion in any detail in this paper.

Mathematics

This is a more complex case, and more interesting still, as the achievements of mathematics are even more distant from its origins.

The basic evolutionary explanation of mathematics is simple. Elementary concepts of number and of geometry are radically tested by natural selection –

Simpson's account of our simian ancestor makes this point concerning geometry. The elementary concepts of logic (formalized reason) are similarly tested: if there is a question here, it is whether they can be effectively distinguished from the elementary concepts of mathematics itself (Lakoff & Núñez, 2000). The evolutionary explanation of advanced mathematics is as a structure built by the application of logic to the basic concepts of number and of geometry. The resulting structure is breathtakingly high, but the tallest skyscraper is made of very simple parts. And to reify it as 'an enduring realm of pure mathematics', as one questioner did, is to revert to what I consider one of the most lastingly damaging legacies of Plato. To the biologically-based thinker, mathematics is not discovery, it's invention. To take Lakoff's & Núñez's book as an example, that volume's sustained theme is that:

> «… human mathematics is not about objectively existing, external mathematical… truths'; *rather it is* 'embodied; … grounded in bodily experience in the world».

The power and success of mathematics in its applications to the world are amazing, but Eugene Wigner's famous phrase about 'unreasonable success' is not quite right. Mathematics is a product of embodied human minds, interacting with the world, so it naturally applies to that world. Its successes are staggering, but they are not, precisely speaking, 'unreasonable'.

Such is the view of the evolutionary epistemologist, as well as of the cognitive scientist, who is in many respects that epistemologist's more empirical successor. I align myself with them both: but let us look a little closer at the cognitive scientist's account of the development of mathematical capacity in the individual. Very young babies give evidence of possessing elementary concepts of number. Even in the first week of life, if simple patterns of two large dots at different separations are successively projected on a screen, the baby's average attention span steadily drops; but if one or three dots are substituted without warning, the baby on average looks at them for considerably longer. The very elementary processes involved in this innate 'number sense' are given the technical name of 'subitizing', to distinguish them from the more sophisticated and extensible processes of rational addition and subtraction (Dehaene, 1997). It would be difficult to imagine a stronger indication of an innate ability to form concepts – indeed, in the case of numbers one to three, innate possession of the concepts themselves. If Konrad Lorenz, before he died in 1989, learned of the early findings of this sort, he must have found them very satisfying.

Science

The most surprising – I am almost inclined to say staggering – challenge has been a suggestion, by more than one commentator, that EE contradicted the possibility of science. Nothing could be further from the truth! The empirical basis of science cannot be at issue. The exploratory and always provisional nature

of human, as well as animal, knowledge, even at the level of the basic generalizations, is a central theme in both EE and the philosophy of science. As to the search for explanations, for the understanding of what is observed, 'Hypothetical Realism', as expounded by Lorenz, Campbell and Vollmer, is so close to the 'Critical Realism' of many modern philosophers of science, that a painstaking study would be required to assess whether there is any practical difference at all.

Perhaps a deeper respect in which EE, as I presented it, was assumed to be incompatible with science was that I was taken to attribute no validity to metaphysics, while many scientific ideas themselves are metaphysical. (Should you doubt that they are, consider first the status of theoretical entities like quarks, or super-strings. Then turn to much more basic physics, and ask yourself about the real existence of a moment of inertia, or how you would set about observing a disembodied force.) But EE does *not* deny the possibility of metaphysical concepts being productive, or even pragmatically valid; these examples from the most exact and therefore 'hardest' of the sciences clearly demonstrate that they are both. If my challengers thought I was denying this, they simply mistook me. I distrust the metaphysical entities of theology, but not science. The reason for the difference is that the utility of the metaphysical concepts of science is subject to the most severe reality-checks countless times each day. Those concerned with other worlds, non-physical states of being, events outside space-time, or the purported structure of the deity – i.e. those of metaphysical theology – are exposed to no such checks. But *that*, not their metaphysical nature as such, is their weakness. Thus Gerhard Vollmer, the surviving High Priest from the 1970's upsurge of German-language EE, recently (2007) stated as his first criterion of a naturalistic, evolutionary programme «*Only as much metaphysics as necessary*». Parsimony, then, with metaphysical concepts, but not dismissal!

The mechanism of evolution

It is convenient to begin this final section also with reference to a past challenger. This one accused me of «*assuming that nothing escapes natural selection*». I accept his substantive point, but not his first word. Natural selection is not an assumption, it is an inescapable fact of existence. *Natural selection cannot not occur!* Where there are two non-identical entities (inorganic *or* organic), the one which is better adapted to its environment cannot fail in the long term to flourish the better. This has been asserted by some critics to be a tautology, because we can most easily measure 'adaptation' or 'fitness' on the basis of capacity to survive (Hull, 1974). The error in this argument is that we biologists have a very clear idea of what is meant by 'fitness', quite independent of our ways of measuring it. The concept is vividly meaningful in principle, but inevitably extremely multi-faceted: countless different factors contribute, and our surmises as to which predominate in a particular ecological situation may well be wrong. So when we measure survival rates, we are not *defining* fitness,

but ascertaining the cumulative effects of its many interacting factors. However, let's suppose one disregards this point, and really does imagine the concept of fitness to be tautologous; the one good thing about tautologies is they are indisputably true! The fitter individual does have a better prospect of survival, and of flourishing.

Perhaps, however, my challenger did not strictly mean 'natural selection', but rather the prior processes producing the variations upon which natural selection inescapably operates: these are what non-biologists are often actually thinking of, when they chant their Devil's mantra, 'Natural Selection'. Maybe variations between generations *aren't* entirely random, as has been assumed in traditional post-Darwinian biology, and less convincingly extrapolated by Popper and Campbell to the formation of ideas. As you will have gathered, I question the latter, but this challenger is right to say that I currently adhere to the former. Yet let it be further clear: my adherence to randomness, in this and previous writings, is *policy, not dogma*. A scientist goes for the simplest explanation until he/she is pretty convinced it isn't adequate. The most valuable of all dissecting instruments is Occam's razor!

Nevertheless, it is right to acknowledge that, in the biology of bodies rather than minds, the last 25 years or so have seen an accelerating number of proposals, based on diverse kinds of observation, that between the DNA and the mature plant or animal – between genotype and phenotype – come an extremely large number of processes which influence the final form. The majority of the new ideas derive from laboratory studies, mainly in molecular biology, and can be grouped under the label 'evo-devo' – the contribution of developmental processes to evolution. Two accessible books in this connection are those of Dover (2002) and Carroll (2005). There are also suggestions, derived from computer modeling and macro-evolutionary observations, that biological systems embody drives to self-organisation and complexity (Kauffman, 1995), and/or to the development of equivalent structures by convergent evolution from diverse genetic bases (Conway-Morris, 2003). Some instances of the latter, notably the occurrence of eyes in many different phyla, were in fact extensively discussed by Darwin, and the concept of self-organisation was first explored productively by Ilya Prigogine in the mid 20th C, but molecular genetics and evo-devo are achievements of the present generation of researchers.

If such complications affect the rest of the body, it must be highly improbable that neuronal development would be free of them. Indeed, there is strong evidence that they do contribute to brain as well as sense-organ formation. Thus it is reasonable to assume that the concept-forming propensities which are the subject matter of EE are in turn as influenced by developmental constraints, convergence and drives to complexity as are anatomy and biochemistry. Being organized and repeating cellular processes these mechanisms are rightly characterized as 'non-random'. However, to the best of present understanding, they are no more caused by mental states, or directed towards the enhancement of intellectual properties, than are genetic recombinations or mutations. From such standpoints they are,

we might say, 'quasi-random'. So if we ask how far these new discoveries affect our previous conclusions, my view is that they simply alter the relative probabilities of different concepts being presented to the test of natural selection: it is this which remains the final arbiter.

At the present stage, therefore, I have been happy to write in terms of the simple, random-variation model, and not complicate the issue. I do not believe the complications would have altered the conclusions. Should future developments prove me wrong, I trust I have nevertheless been clear. My guide has been Bacon's maxim: «*Truth springs more readily from error than from confusion*».

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II. SESSION PROCEEDINGS

Presentation

Prof. Spurway began by thanking the members of the Sophia-Iberia team for inviting him to participate in the Seminar. He then proceeded to read his paper, (a draft of which had been already handed out to the audience) although he would skip some paragraphs and make a few other small deviations. We offer a summary of his oral presentation:

Biology as a starting point

An agreement on some starting point is necessary for any dialogue to take place, and Spurway proposed the Darwinian perspective as such a starting point, which has been adopted by many thinkers (Konrad Lorenz, Gerhard Vollmer, Karl Popper, Donald Campbell, Peter Munz, etc.) The general position to which these thinkers contributed has been known since the 70's as Evolutionary Epistemology, abbreviated to EE, an attempt to work out the implications of evolution for knowledge itself. It assumes that at the level of immediate causes human beings are as totally the products of evolution as any other living form, so that all systems in our bodies – including sensory and nervous systems – and therefore also our mental functions are products of natural selection.

Sensory and brain mechanisms

The evolutionary viewpoint explains the limitations of our sensory and mental capacities and also provides an assurance that our perceptions and judgements about the material world are reasonably reliable. For instance the ranges of our seeing and hearing capacities are completely honed to what we need to see and hear in our environment, while other species have other sensitive ranges, more appropriate to their own needs. For each species some specific sensitive ranges have been achieved, determined mainly by the evolutionary cost/benefit ratio, that is to say, their organs have developed in order to take into account those aspects of reality that were important for their survival, as long as the energy invested for that development was worth the gain that was going to be obtained by it.

Something similar has happened with the brains. Big areas of the sensory cortex are devoted to the more relevant functions (in humans the areas sensitive to touch of the lips, thumb and finger tips are much larger than those for the limbs and trunk) and each species has also reached its own Encephalisation Quotient (brain volume/body volume ratio), depending on the cost/benefit ratio involved in this development: humans have the highest existing EQs, though they were matched in the past by those of Neanderthals. But we find another selective shaping of the nervous systems occurring in the individual human brain

by the environment's influences and the organism's requirements during the last months before birth and the first 1-2 years after it. During this period many unused nerve-nerve (synapses) are eliminated, while others are enlarged; the time-scale is very rapid compared with that of the genetic evolution, yet the process still follows the Darwinian principle: development of what is useful and elimination of what is not. Natural selection operating at these two levels means that not just our physical organs but also our mental 'organs' have been selected by their contributions to the survival of the individual and the species.

Adaptation for survival and innate ideas

An important aspect of this evolutionary perspective is that our capacity for geometrical and physical judgements, as well as biological and sociological ones, has been proved to be a reliable one by our own survival (and the reproductive success of the network of ancestors we have emerged from). A key instance is spatial judgement: if this had not been very accurate, over at least the last 30 million years, the tree-dwelling monkeys and apes would have fallen to their deaths and could not have become our forebears. Our genetic disposition and subsequent synaptic competition enables us to respond to particular forms of regularities in our physical and social environments. Not only our perception but also the way we make our concepts (at least those which have direct survival consequences) must be reasonably accurate, giving us an adequate knowledge of our world (though imperfect and incomplete).

Empiricists (such as John Locke) denied the existence of innate ideas in the human beings while the opposite school, the Idealists (from Plato to Kant), maintained that we have at least some *a priori* concepts. The EE perspective contends that what is inborn in the individual has arisen by the accumulated actions of natural selection upon countless generations of ancestors. So this innate cognitive structure is *a priori* for the individual, but *a posteriori* for the species (based upon the ancestors' experience).

Exploratory knowledge

But our species' intellectual progress is not restricted to DNA mutations and synapse elimination. Mainstream evolutionary epistemologists, such as Lorenz and Vollmer, argue for 'hypothetical realism', an epistemological stance which regards each concept we form as a hypothesis about the world. If the concepts are proved inadequate they (or we, should the error have lethal consequences) are eliminated. Popper took this idea forward to further explore the process of knowledge advancement in organized human societies. He maintained that hypotheses can never be proved, but should be stated so that their predictions can be made susceptible to be proved or refuted. This conscious level of conjecture and refutation was also taken into account by Campbell and Munz when using the term EE. However this would be a case of cultural, not biological, evolution.

Therefore we have two kinds of EE, distinguished (by Michael Bradie) as 'EEM' and 'EET'. The earlier authors in the field developed EE in reference to the biological processes that affect the unconscious propensity to form basic concepts and the natural selection of the more adequate ones for survival: Bradie calls this EEM, 'M' making reference to 'mechanisms' that act through DNA. When EE refers to the conscious formulation of hypothesis and mental rejection of some of them, he calls it EET, corresponding to a quicker evolution that acts through culture, where the 'T' stands for 'theories'. The two modes of learning differ in respect to consciousness and speed, but neither of them implies that a model of the external world is imposed by that world upon the living being; instead, the organism always, unconsciously or consciously, submit its latest 'hypothesis' to the rigorous challenge of the world. The biological mode of learning may be applied to all kind of organisms, even without nervous systems, which by natural selection become increasingly adapted to the world, so that in some sense they 'acquire information' about it. The process at that level is entirely unconscious and entirely random. But animals with nervous systems and effective societies would embody both modes of learning.

Animal learning

Behavioural experiments show strong indications that elementary trial-and-error learning occurs in all kind of animals with nervous systems, as Popper assumed. However, another common observation is habituation, the reduction of response to a repeated stimulus. Then there are conditioned reflexes, on which Ivan Pavlov built his whole approach to the study of mind. Many vertebrates also learn diverse skills by copying, usually from their parents. In addition humans have a specific mode of transferring knowledge: language. Non-neural learning, passed on to the new generations in the genome, cannot be other than by random mutation and natural selection, but we have just noted several forms of direct knowledge-acquisition in the case of animals endowed with sensory-nervous systems. *Contra* Popper, Campbell and Munz, it is not possible to describe all these processes of knowledge acquisition in terms of 'random conjecture and selective retention'. Nevertheless Prof. Spurway has come to believe that what matters is not how concepts are arrived at, but how they survive. And EE contends that only those which withstand the filter of natural selection (being more or less right or at least not wrong in an important way) can survive.

Competing philosophical and psychological approaches

Mainstream epistemology searches the characteristics that justify a belief (as true), aspiring to prescribe how knowledge should be acquired so that it can be trusted. But EE provides justification for a concept (as a reliable hypothesis for practical purposes) looking to its role for survival, rather than to the way it was

obtained. Thus, EE (more specifically EEM) offers good reason to believe that our perception of the world is objectively real and our fundamental concepts are useful approaches to it, and then our understanding can be extended by formulating conjectures subject to experiential test (EET). The claims by Popper-Campbell-Munz that all learning occurs by implicit or explicit hypotheses being tested and that this process is initially completely random are the most criticized by other philosophers. The contrasting opinion contends that while this is the case with EEM, at the level of EET only hypotheses with some prospect of success are formulated, and this process is not totally random.

From knowledge to reason

So far EE's stance about knowledge and concepts has been presented, but nothing has been said explicitly about 'reason'. An important distinction in that direction would be the one between 'knowing how' and 'knowing that'. Through their learning animals mainly acquire 'knowledge how' (skills to hunt, escape, sing...) and even the concepts ('knowledge that') taken into account in the case of human learning are tested by natural selection only in terms of the behaviour they lead to. Therefore, 'knowledge how' seems to be primary and 'knowledge that' derivative, usually seen as an abstraction or generalization of some forms of the 'how' knowledge.

Reason can be defined as the capacity for handling concepts. As already discussed, experience is essential for arriving at knowledge, but reason is also necessary to the resultant formulation of concepts. Anyway the propensities to acquire factual knowledge, to form concepts and to reason about them are closely intertwined, so the evolutions of all of them must have been intertwined too. Besides, it is important to stress that the word 'reason' is an envelope term covering many capacities, that are developed to different extents and at different rates in different groups (and different individuals), always relating that development to the enhancement of survival.

Prof. Spurway quoted then Konrad Talmont-Kaminsky to support the existence of a continuum of epistemic methods from the mechanisms used by unicellular beings to our everyday complex uses of perception and further yet to the highly specific methods used in science. Reason needs to be studied in the concrete context of actual reasoning beings instead of being considered as just an abstract set of rules and relations. Neurological studies show that perception is highly constructive, focused on providing the minimum adequate information to facilitate the decisions for immediate action, and this process constitutes reason in practice. For rationality to be explained entirely in biological ways it should be studied in those simple goal-seeking everyday behaviours out of which it emerged. As argued by Henry Plotkin, intelligence (based in neural networks) probably evolved so that the species could deal with new fluctuations of the environment that were too fine or too fast to be efficiently followed by the merely genetic adaptive mechanisms of evolution.

Prof. Spurway then thanked the audience for their interest, inviting them to regard the programme he had outlined as a form of 'thought' experiment, exploring how far it is possible to explain the evolution of our mental processes, including reason, in terms of natural selection.

First Questions

Javier Leach, acting as moderator, opened the floor for questions from the audience.

Carlos Castrodeza: *'Knowing that' related to the contemplation of one's own death.*

Carlos Castrodeza asked the lecturer about the concepts 'knowing how'/'knowing that', suggesting that 'knowing that' would be a typical human adaptation for survival, in the sense that humans are the only organisms that can contemplate their own death. A biological contradiction arises here, because in a sense one is programmed to survive, and in another sense one contemplates one's own death. A way of implementing this contradiction would be just to develop the 'knowing that' dimension (which includes theology, philosophy, science). He then asked Spurway if he would agree with this.

Neil Spurway said he agrees totally, but he suspects that some of the other higher mammals also have some very primitive 'knowledge that', although certainly not anticipation of death.

Javier Monserrat: *Sensitivity/consciousness and computational models.*

Javier Monserrat thanked Spurway for his presentation and then affirmed that today there is not really an alternative to the Darwinian perspective. He commented that the presentation had outlined the main features of Evolutionary Epistemology (EE), but we should understand the big importance of the fact that some beings (particularly human beings) have the existential quality (ontology) of sensitivity – even consciousness in the case of humans and other higher animals. The point of view of EE should then also be understood in connection with this fact (all animals with sensitivity, higher animals with consciousness). Many professors (in the United States, England, Spain... in the Psychological Faculties...) think that many of the features of human behaviour could be explained and understood in terms of purely computational behaviour. For them, natural selection would only be the result of mechanical adaptation to the world. The fact that we have sensitivity and consciousness would only be an epiphenomenal fact, but there would not be a real causation for this fact in the natural adaptation. EE is certainly not a computational theory about humans and animals. The question is then what role this important fact does play in EE, the fact that sensitivity has a real causation to explain all these features: adaptation and so on... How could we understand this fact from an EE point of view? And how could we argue against this important computational understanding of man?

Neil Spurway affirmed that Monserrat is right when assuming that EE in general does not commit itself to a mechanistic explanation, though not in any other directions either, it is agnostic on that point. Some evolutionary epistemologists (such as Gerhard Vollmer) are radical ontological naturalists – Vollmer does clearly look to computational models to explain all psychological processes – but equally clearly some others (like Karl Popper) do not. Remember Popper's 'three worlds' ontology. Most of the others leave the matter as not touchable by evolutionary considerations and therefore not part of what they are

directly talking about. Regarding now Spurway's own view, he wanted to suggest a difficult stance, but one which (if we were to use Hegelian language for a moment) might be a synthesis out of the thesis and antithesis of a purely mechanistic or a totally different causative consciousness, the absolute opposite of a mere epiphenomenon. Spurway's own stance, not as an evolutionary epistemologist but as a physiologist of fifty years standing, if we were to use a traditional philosophical label would be that of monism, but *dual aspect* monism. In ways that we might never understand, both the mechanistic account, the observers', experimental neurophysiologists' account, the 'brain-story' (as British philosophical brain scientist Donald MacKay used to call it) on the one hand and the 'I-story' (me, the subjective aware individual), both these stories are concurrently true, they are two sides of the same coin. And any notion that giving one account excludes the other is a mistake. Prof. Spurway cannot suggest how in any detailed instance the two accounts or viewpoints can be of one and the same process, but he does fundamentally believe that they are and that gradually, though probably never completely, the various different approaches, the psychological one and that of the neurosciences will therefore converge. This is of course an act of faith, something that he cannot prove.

Carlos Castrodeza: ***The neutralist alternative to Darwinian orthodoxy.***

Carlos Castrodeza agreed that Spurway's perspective is a Darwinian perspective, but he proposed that a more accurate concept would perhaps be a naturalistic perspective. In the sense that nowadays there are alternatives to Darwinian orthodoxy, which are completely legitimated from a scientific point of view. For instance, the neutralist interpretation where the natural selection would give the final touches, it would not build the entire building of life, but after random walk of course there must be natural selection, by definition. There are two other alternatives Darwin had to contest with in his notebooks, the neutralist alternative which was the German alternative, Leopold von Buch was exploring this alternative in the diversifications of plants and animals in the Canary Islands, and then Lamarck, not in his *inheritance of acquired characteristics* but in his *evolutionary theories*, developed recently by Stuart Kauffman of the Santa Fe Institute. Although Darwinian orthodoxy dominates the landscape, Castrodeza thinks these other two approaches should be included in the setup, and perhaps we should talk of 'the Darwinian interpretation' in a metaphoric sense, but in a truer sense of 'the naturalistic interpretation'.

Neil Spurway pointed out that neutral mutations, or rather, neutral 'variations' are actually discussed by Darwin in *The Origin of Species*, and in fact he himself had implicitly referred to them when he mentioned 'adaptations with advantages or at least not disadvantages' – the 'at least not' indicating the neutral ones. Of course they occur, and only the ones that are disadvantageous are selected against. Quite a lot of the oddities of species development are explained by neutral modifications – 'descent with modification' was after all Darwin's own phrase. The concept of natural selection, which was Darwin's original contribution to our understanding, refers to what happens after the mutation or other variation has occurred (in species with sexual reproduction a variation may occur by the mixture of existing genes, not necessarily mutation).

So natural selection is the *post-hoc* stage of the overall evolutionary process. When talking of Stuart Kauffman (whom he, Spurway, has read and reviewed very favourably for ESSSAT), we are considering the preliminary stage, the stage of what causes the variations. And he admitted to knowing Kauffman much better than the 19th century German precursors but certainly fully recognizes that Kauffman is just the latest in a

long chain. He then contends that we are not saying anything contrary to natural selection, we are talking about what is the totality of variation to which natural selection will then apply. He then pointed out that in the last paragraph of his full text he shows extreme interest in Stuart Kauffman's thought. He is much more interested in that, than in some other wild hypothesis, such as morphogenetic fields influencing the way genes behave, or even the totally way-out suggestion that life came from other planets, which doesn't solve anything because actually it's still got to start somewhere: Stuart Kauffman says something a lot more interesting than any of those. For the moment, Spurway said, he writes in terms of random mutation not guided by any influence of complexity, because this involves no assumptions. He thinks that Stuart Kauffman gives no suggestion on how complexity does guide mutation. In a sense Kauffman's proposals are easier to understand mechanistically, first of all in the simple chemical instances with which he begins, and then in economics with which he ends. It's least evident how he thinks that the drive to complexity actually influences genetic events, but nonetheless time might produce accounts of how this could occur.

Anyway, none of this matters fundamentally, because what he has been talking about is that however the mutations occur, whether they come down to future generations or not will be a matter of natural selection, and natural selection cannot not occur! The better adapted individual is bound to have a better chance of surviving and producing progeny. This natural selection is what he has been talking about not the mechanism of the mutation.

CARLOS CASTRODEZA thanked Prof. Spurway for the answer.

JAVIER LEACH: *'Knowing that' as a typically human objectification of reality.*

JAVIER LEACH asked about the concepts 'knowing how'/'knowing that', suggesting that there are strong relationships between both. As an example from mathematics: 'knowing how' is algorithmic knowledge – it's a process, it's when you know how to do something – and 'knowing that' is the proof. We know today that the proof is also an algorithm, because we have to know how to prove. The big difference is that when we 'know that' we objectify, we separate something from us, as an object, somehow, and this is a very typical human characteristic. He then said that, in his opinion, what makes us human is that we objectify reality, that we see it from outside.

NEIL SPURWAY acknowledged that Leach kindly had given him e-mail warning about this interesting question a few days in advance, but he admitted that he still did not have an answer to it from the long perspective. The one thing that seems to him pretty clear from this mathematical example is that this issue arises entirely within the realms of EET, it's theoretical, it's the intellectual world that Popper is talking about, not the physical world that Lorenz, Vollmer, etc. are talking about. He declared himself happy to accept (after a short period of thinking about it) that within the theoretical world, 'knowledge how' and 'knowledge that' are probably only practical not fundamental distinctions. But he still suspects that at a more primitive level, they may be fundamental. Yet he hoped to give it further consideration.

JAVIER LEACH then said that on the next day we would have more time for a deeper discussion and thanked everybody for their assistance and participation.

III. JAVIER MONSERRAT'S SUMMARY OF SESSIONS I-IV

With the presence here with us today of Professor Spurway we conclude the first Sophia Iberia seminar on *ontology and evolutionary genesis of reason*. We thank Professor Spurway again for his participation in the seminar. To enter the discussion of his presentation we can do a brief summary of the path along the encounter with the seven professors who have visited us. But the road had a clear objective: to know from a scientific perspective the ontology and the evolutionary origins of reason. Therefore, we will remember the purpose of the seminar, before summing up the response given by each of the seven professors and at the same time, the essential features of the discussion of their contributions.

REASON

Reason is a personal and social experience. It has various manifestations. One of them is science. We can describe it according to a phenomenological method. It is therefore a fact, a *factum* that must be explained by knowledge of the causes that have produced it. Therefore the seminar's goal was knowledge of the explanation of the origin of reason in a scientific perspective.

I need not to recall here the importance of the scientific knowledge of reason. There is no science without epistemology, since science is a product of knowledge. There is no metaphysics without natural or philosophical exercise of reason. Man cannot responsibly address the meaning of life without acting in any way the faculty of reason. Similarly, the metaphysical language about God in philosophy or theology depends on an exercise of reason that is produced from the evolutionarily ontology that determines the way it operates. So, what is reason? What is its nature? What evolutionary causes explain that it has been produced in the human species? Its nature and evolutionary origin, how does it explain the operative functioning of reason (in whatever form, for example in science)?

ROBERTO POLI

University of Trento, Italy

Poli has contributed from the perspective of his interest in epistemology and ontology. But, what is reason? Roberto Poli's response has been: reason should be considered in the context of the ontology of life. However, the functional ontology of life responds to the functional structure of an anticipative system. Therefore, reason should be understood as a product of life as a system. Systems theory would be the epistemological framework in which to understand the functional nature of reason.

In this sense, the theory of systems (structures) a) could help to describe the nature and operation of human reason as «representative process for analysis and synthesis of systems (structures)»; b) the evolutionary process leading to emergence of reason could be understood in terms of the formation of successive mechanisms

of increasingly complex systems analysis. Action toward survival (response) would then depend on a prior «systems analysis» (systems representation).

It seems in general to be thought that the origin and nature of reason has to do with the fact that the universe is a structure (or system of structures). Life, and therefore reason, should be read in conjunction with the idea of «structure» (or «system») and, as a consequence, in relation to the formal sciences in general. Not only with the theory of systems. It will probably be necessary to reflect further on the concept of structure, system dynamics and structures and systems (in complementary and interdisciplinary connection with various formal sciences).

GREGOR NICKEL
Siegen University, Germany

Nickel has contributed from the perspective of formal sciences, and more particularly from mathematics. So, what is reason? Nickel responded that mathematical reason is a free creation of the mind. Although a part of mathematics has been applied to the explanation of the deterministic world of physics, however, mathematics is not constrained by the physics of a deterministic world. It's free and creates worlds that do not depend on experience. But we go back to the main question: Why is reason creative? What are the real causes that produced it? Nickel's response pointed out to a theoretical background under the classic Kantian aprioric theory of mind. However, in discussion with Nickel a possibility was raised of explaining the origin of the free and creative reason from the perspective of an evolutionary epistemology that would connect with the systems theory: the world is a structure (system) and reason fights to survive by the analysis and synthesis of systems. This structural analysis would enable the right to creatively imagine new forms and structures (formal sciences).

Professor Gregor Nickel raised doubts as to any «naturalistic» explanation of reason, on the claim that natural sciences are written in the language of mathematics and the consequent mathematical dependence of physics. Nickel argued in favour of releasing mathematics of «naturalism», conceiving mathematics as a free creation of reason and viewing mathematics as an extreme example of autonomous self-reflection on its own based on that freedom.

Notwithstanding we can provide some consistent assumptions about the causes of the evolutionary emergence of the «freedom of the mathematical mind». A) On the one hand, natural reason is systemic (structural). The traditional mathematical reason has also been, as a fact, a systemic analysis of space-time in geometry and arithmetics. It is therefore possible to assume that this «systemic habit» of reason has qualified mathematical reason to construct «imaginary structures» and «abstract formal systems». The transition from the concrete to the abstract is a natural process of the mind that has been described by epistemology in various fields. B) Furthermore, this real space-time experience probably empowers natural and mathematical reason to understand that the macroscopic classical world does not exhaust all of reality. There could be types

of reality that are not correctly described by classical mathematics and are needed to be described by new formal systems. This way mathematical reason would be impelled to find and intuitively create and imagine new systems, structures and forms of reality. Consequently, both the systemic experience of a classical space-time and the experience of the whole of reality would open the human mind towards a horizon of creativity, imagination and freedom.

HARALD WALACH
Northampton University, England

Walach contributed from the perspective of psychology and, especially, from his previous interest in the possibility of applying the physical principle of complementarity of quantum mechanics to psychology, so that one could speak of a psychological experience of entanglement. If these assumptions of Walach are correct, then what do they mean in order to explain the nature and the functional form of reason? What is reason? The discussion of the ideas of Walach led to an important consequence. It is supposed that reason is evolutionarily shaped like a survival instrument adapted to the objective world, but always according to the experience we have of this world. So we come to a consequence: if the experience of the world is a) an experience of a physical structure (or system) and b) a holistic experience of entanglement, then reason should operate a) in the form of systems analysis and synthesis and b) as knowledge of holistic fields of reality (in which reason is immersed by entanglement). The experience of a structural world has favored the rational understanding in classical physics, mechanical and deterministic. But the holistic experience has favored reason in ordinary knowledge (language and poetry). Science would need, however, new formal models for describing the holistic world of quantum mechanics. Therefore, reason is not only dependent on its evolutionary development from the experience of a structural world (Poli), but also from the experience of a holistic world by entanglement (Wallach).

The contribution of Walach has shown how the human being is open to a dual, but complementary, experience of reality. Not only physical reality in physics is experienced as complementary (the wave-corpuscle irreducibility). The general principle of complementarity means that the psychological experience of reality is also open to a dual experience: a deterministic physical world of individual differentiated particles and a holistic world that Walach describes as a generalized experience of entanglement (PDR effects). Applying the principle that not only humans but also life in its evolutionary process (at different levels of sensitivity-consciousness) has this dual/complementary experience of reality, we could thus be led to believe that reason has been produced by this dual experience. In other words: the evolutionary causes of reason would not only be the experience of a differentiated/deterministic world (classical), but also the experience of a holistic world by entanglement (quantum).

Admitting the existence of an irreducible complementarity as a fact does not imply giving up the existence of an «unitary explanation» of the physical world.

About forty years ago an intensive search for that «unitary explanation» began. In physics, scientists were attempting to find a new conceptual framework through string theory (not the only alternative today, and besides more than debatable). This new «unitary explanation» should overcome the irreducibility of the two complementary images of physical reality (classical/quantum). But it is not only this: today scientists are trying to link the two dimensions of physical reality (classical/quantum) with the two complementary dimensions of psychological experience (psychological/physical and mind/body), described by Walach. The physical/body dimension would relate to the classical world and the psychical/mental dimension would relate to the quantum world. Therefore, the classical/quantum «unitary explanation» would also facilitate a psycho/physical «unitary explanation» (the mind/body problem). In this way the new holistic physics that is today in its infancy would be born.

MANUEL CURADO
Minho University, Portugal

Curado contributed from the perspective of epistemology, philosophy and theory of mind. So, what is reason? Curado's response has been: it is not possible to describe a universal and absolute rationality because it always depends on a) its locality (the «real niche» where it occurs) and b) the multiplicity of rational beings in whose mind rationality is built. However, reason is evolutionarily adaptive to the environment and once located in a «real niche» it is constrained by the objective conditions of the physical world. Therefore, the rationality of the «rational beings» who share the same physical media tends to present some same characteristics (all equally imposed by the same local physical environment). The world thus has a logical depth that rational beings will try to reproduce in their minds. Curado thinks that this logical depth of the world is computational and, consequently, the mind tries to replicate plots of reality in computational representations (science). However, there is always an ultimate irreducible rationality, specific, inevitably depending on the multiplicity of human beings who create that precise rationality.

Therefore, Curado highlights the following common elements among the rational structures of the different peoples on Earth: 1. Rationality does not duplicate the world, but acts selectively, in a biased and simplifying manner. As we see especially with science, rationality tries to find an **algorithmically compressed** way to duplicate most natural processes. 2. **Locality** is another common characteristic to our rational structures, that is to say, in order for us to know something we don't need to know everything in the universe. 3. Human rationality has a high degree of **logical depth**. The world we live in has a parallel level of logical depth. 4. It is also important to take into account the **multiplicity of rational beings**.

'To evolve' means to search possible structures inside a universe, with the principles of economics, sparseness and computation. These principles have something to do with the computational constraints that are common to nature

and thought. Rationality is not, therefore, an evolutionary accident. The enormously big number of random events that produce each evolutionary step occur only in the small details because the overall logic of evolution imposes itself on all processes.

Discussing Curado's analysis, the physical environment of the world (considering the world as a global «real niche») that imposes common constraints to the rationality of all human beings could have universal and repeated characteristics. Then it would be justified to speak of a common rationality in humans. But, considering the special characteristics of different localities in the world, it would be also justified to speak of «local rationalities», much more if we consider the multitude of rational beings who should build rationality in their minds. However, would these natural constraints always be computational (systemic/structural in the sense of Poli)? Should we not consider the constrictions of a holistic experience of reality by entanglement (in the sense of Walach)? Should we not consider the interactive and unifying action of culture in the process of creating individual rationalities?

FRANCISCO MORA
Universidad Complutense de Madrid, Spain

Mora contributed from the perspective of medical neurology. What is reason? Mora's response has been: it is the result of the interaction of complex neural networks or circuits that represent the world from sensations and elementary experiences. Reason is thus an adaptive function of the brain, always focused on survival in the environment. But to understand what reason is we should not only address the complex forms of representation in the human world, but we must also connect reason with emotions. Thus we can say that the cause that produces reason is the possession of a rational-emotional brain, connected by the nervous system and sensory systems with their own bodies and with the outside world.

The process that has built the body-brain system in order to enhance animal survival can be followed in an evolutionary perspective. Brain evolution in the zoological scale, ranging from less perfect to more perfect, makes clear that the development has consisted of building brain designs to control the body. Sensitive systems gradually appear, internal and external agencies that make you feel your own body and at the same time receive sensitive information (feelings) of the environment in which each being must survive by adaptation. The first automatic adjustment functions (mechanical) evolve to higher animals. Representative functions and memory appear in the animal world and are the foundation of the higher representative processes that occur in humans. The whole process has been shaping the brain with multiple circuits (patterns) recalling what has been perceived (the world and the self) and trying to represent what has been felt/perceived. But the image of the world (the environment and the body or I) has been born evolutionarily in connection with «emotional values» assigned in the brain to the sensory and the representative world. This assignment of values (or valences) is always a function of adaptive survival. Therefore, it is never

possible to understand the human exercise of reason when it analyzes and builds its representation of the world, regardless of the emotional roots and emotional functioning of our representational world. The value system of values and representations produces the emotional world and is, at the same time, an evolutionary instrument at the service of emotions.

CAMILO JOSÉ CELA-CONDE
Universitat de les Illes Balears, Spain

Cela-Conde contributed reporting from the perspective of paleoanthropology and experimental neurology, with the method of magneto-electro-encephalography. What is reason? The response of Cela-Conde has been: reason is the result, first, of an enrichment representative process oriented to adaptive action; a process that can be reconstructed from the data currently available in paleontology and paleoanthropology. But, second, the causation of this behavior is always progressively depending on the evolution of the brain and the neural record of increasingly complex patterns. These patterns depend on sense experience and allow an experience of the environment more and more perfect. The neural support of these patterns linked to the ratio-emotional activity can be detected today by the method of electro-encephalography and presumably these patterns are located in modules that began to be formed in the primitive man.

The paleoanthropologic evidence that reason is an emergence process can be followed from the first steps of the genus Homo. The use of working tools, the more complex communication and social interaction and the enrichment of language, first by pure signs and later by phonetic emission of complex signals, are the most important traces of the emergence of reason. The primitive mind is capable of analyzing the facts, to draw and imagine or anticipate future events and plans for adaptive behavior. In this protohistory of the brain began to be formed the neural patterns that produce the knowledge of the environment for survival, ethical-moral principles for social coexistence of the group and the aesthetic emotions. This can be attested by the implications of social rules in primitive groups and the artistic works that they have left us. These ethical and aesthetic activities formed the brain localizations that we have today, as noticed by magneto-encephalography and continue to exert their influence on modern man.

CONCLUSION

What is reason? What does science tell us about the evolutionary causes that have led to the emergence of reason, its nature and its way of operating in the production of mental representations, real, imaginary or formal? The seven professors who have participated in the seminar have provided complementary approaches.

Roberto Poli: Reason is a consequence of life as an anticipative system and consists of the formation of representations of the world by analysis and synthesis of systems (structures).

GREGOR NICKEL: Mathematical (formal) reason is independent of the constraints of a physical deterministic nature but answers to a faculty of the mind that allows creative freedom and formal imagination.

HARALD WALACH: The environment surrounding man is not only a mechanical but also a holistic field that is sensed by entanglement and that's why the emergence of natural reason and science is conditioned by the psychological holistic experience.

MANUEL CURADO: Reason has an evolutionary origin and, therefore, it is always a local rationality built on concrete individuals. Each «locality», however, reflects an objective mechanical-computational world which imposes certain common constrains to which all living beings must adapt to survive in such a locality.

FRANCISCO MORA: Reason has been built evolutionarily as a mapping of circuits or neural patterns in order to an adaptive survival and to maintain the service of the basic emotional values.

CAMILO JOSÉ CELA-CONDE: Reason shows its genesis in the evolution of primitive man as an instrument of domination of the environment in the world, as a representation of ethical behavior in the group and as the aesthetic experience in space and time. Primitive man has shaped the brain localizations and we can now check them neurologically.

NEIL SPURWAY: Reason is an adaptive product of organisms to the environment in accordance with the principles of Darwinian natural selection, as they have been exposed in Evolutionary Epistemology.

Could we try a synthesis among these complementary approaches?

Reason is a product of life in accordance with the principles of Darwinian natural selection. In this adaptation both the sensitive ontology of life and the determinist and rigid mechanical structures of physical bodies have played an essential role. The objective environment to which organisms have adapted has always had a precise «locality» and rationality is the work of individual agencies, although the interaction of heredity, common environmental constraints and the influence of the species (of culture) should also be considered. The constraints of the environment are, first, the mechanical and computational structure of the world and, second, the holistic experience of entanglement. An objective world system (partly mechanical and deterministic) has produced, in consequence, the operations of reason as analysis and synthesis of systems (so in science, mainly in classical mechanics). But a world of holistic experiences has produced life experience in the world, social unity, ordinary knowledge, art and poetry, and now major parts of science, as it is in quantum mechanics. The structure of the world experience and the enigma of the holistic ontology of reality have released the human imagination in science and in the free creation of formal universes. The discourse of reason emerged and is founded in the earliest stages of human evolution and, above all, in ethical and aesthetic experiences where man is connected to the cosmos in freedom and the holistic experience of entanglement. All this rich world of the mind through sensory experiences and representations designed to fit correctly the objective world, was made possible by the neural

mapping of the brain that supports the psycho-bio-physical activity of mind. That neural mapping serves to connect reason with the emotions of the species in order to strengthen the adaptive values of life.

IV. DEBATE WITH NEIL SPURWAY

JAVIER MONSERRAT first offered a summary of the previous sessions of the First Academic Seminar (see above). At the end of it he added that the goal of this seminar was only to think about the nature and evolutionary origin of reason from the perspective of classical neurology. It was excluded in advance to deal with very important problems in connection with the so-called quantum neurology. The question of how consciousness and sensations are produced from the physical world is a question that will be approached in Sophia-Iberia's next seminar. He also commented that, from the perspective of the fifth and last session, the seminar has been really interesting. A remarkable complementarity has been certainly found among all the contributing professors and Neil Spurway has indeed put the final cherry on the cake. In Monserrat's opinion, this last contribution has been fundamental, because the basis of the whole seminar has been the Darwinian theory and its role had been especially well presented in Spurway's talk the previous day.

Prof. Monserrat then opened the floor for contributions, inviting first Prof. Spurway to share his thoughts about the problems dealt with during the previous sessions.

Neil Spurway's comments about sessions I to IV

NEIL SPURWAY affirmed first that in a very considerable measure he is in agreement with the last three speakers, Curado, Mora and Cela Conde, as their positions are relatively biological and evolutionary. He would just make a minor correction to Cela Conde's idea that primitive man had shaped the brain localizations, saying that, in his opinion, it had been just the other way around. However, regarding the speakers who happened to be the first three chronologically, he wanted to raise some questions.

Regarding Roberto Poli's talk, as a scientist Spurway feels uneasy about the notion of anticipative systems, rather than responsive ones. From an ontological point of view the notion of anticipative design is entirely acceptable, indeed hard to do without. But science cannot show that the evolutionary process has an anticipative feature, something designed in, pointing it in a particular direction. Stuart Kauffman had considered the possibility that there is some sort of anticipative pressure towards complexity, but Spurway said he is very much agnostic about that point and that the previous day he had the chance to explore to its limits the notion of evolution as an entirely responsive system. So, he puts a question mark about whether the notion of anticipative systems theory can really be scientific, although he has no problem with the use of this notion in ontology or metaphysics and he is largely in agreement with everything else that is implied.

Gregor Nickel had been reluctant to accept that mathematics is a product of biological evolution and the basic notion Spurway wanted to propose about this point is actually

in a section of his paper that he hadn't read the previous night. Very fundamental concepts of geometry and mathematics are inherent in the human brain, and indeed there are some indications of very elementary concepts being inherent in some other animals, for instance primates and dolphins. Some of the work done by Lakoff & Núñez and by Dehaene, on 'number sense' in human babies, demonstrates that in their first week of life they have some ability to distinguish 1, 2 and 3. To avoid any suggestion that they have the adult faculty of counting, Dehaene calls this 'subitizing', rather than counting, trying thereby to make an entirely objective description of this skill, which indicates some absolutely fundamental innate sense of number. A lot of Spurway's examples the previous day had also concerned our innate sense of geometry and of space. The question he would like to put to Gregor Nickel is whether he can convincingly defend the view that it is impossible for reason gradually to develop, from these very basic concepts, all the fantastic structures of advanced, modern mathematics. It is exciting and challenging to notice that geometry and algebra, which were developed entirely as imaginative mathematical structures, proved generations later to be applicable to the physical world in a manner that was not foreseen at all by the originators of the mathematics. Looking always for the simplest evolutionary explanation, Spurway feels that it is perfectly possible to conceive that, building from very fundamental evolutionarily-reinforced building blocks, the fantastic structure of modern mathematics is nonetheless linked to and derived from the biological world and not something entirely separate and imposed upon it.

About Harald Walach's introduction of the notion of quantum phenomena into the consideration of consciousness Spurway felt utterly unpersuaded. Firstly, any form of quantum event involves energy many orders of magnitude less than the events at a single synapse. There is no evidence that there are systems in the brain capable of the degree of amplification that would be necessary for a quantum event actually to influence a synaptic one. When Walach goes as far as to talk about 'entanglement', he is several orders of magnitude more remote still, in Spurway's opinion. These are his practical questions about the applicability of quantum theory. But he has a more fundamental one still, wondering how such an application helps. Walach seems to feel (as have many other people for the last couple of generations) that if you can bring in the quantum, somehow you have explained consciousness. In Spurway's view you have done no such thing. There is nothing more conscious about a quantum event than a classical physical event. In either case, whether classical or quantum, we would still have to present some sort of picture of where the self-awareness, the consciousness, the «I-story», as distinct from the «brain-story», comes in; as in Spurway's notion of dual aspect monism, of the two sides of the same coin.

Clarifying Roberto Poli's position and other possibilities of 'anticipation'

Javier Monserrat commented that he sees no contradiction between the possibility of applying the concept of 'anticipative systems' (from system theory) to biological systems and the general principle of a Darwinian understanding of evolution. We can easily understand that evolution has designed these biological systems so that by this mechanism of anticipating the world they can be better adapted to the environment. For example, chameleons do not have consciousness; they have sensitive experiences but do not have a brain that makes them able to have an image of themselves. However, in a certain sense their neural system shows anticipation: if in their vision they see a fly, they can react immediately because their neural system anticipates something. In the case of dogs, if they are shown a sign, they anticipate a certain situation. With a little sign a dog knows, for example, that his master will put some food in a certain place. We can cite many

experiences of anticipative systems in the biological world, and this is so, because, in Monserrat's opinion, by adaptation the living beings have got to develop these anticipative systems. This idea of anticipative systems should not be considered as something that has nothing to do with biology: it is completely coherent with Darwin's theory of natural selection, so that Monserrat thinks that it is a good idea taken from system theory to be applied into biology and that this was Roberto Poli's intention.

Neil Spurway totally agreed that the nervous systems that have evolved well before the achievement of consciousness (as far as we can identify it), are equipped with the power of anticipation, and this has an adaptive value. They are possible because of the regularities of the world; therefore they have been capable of evolving in response to those regularities. Spurway was disputing not that individual brain structures (conscious or otherwise) have the ability to anticipate, but the notion (that he understood had been presented as a scientific hypothesis by Poli) that the whole process of evolution has been planned in response to some anticipating overall design. It may be so from a metaphysical standpoint, but Spurway thinks science cannot use that idea, or at least that it is really dangerous trying to do so because it is likely to become obscurantist, rather than clarifying. He feels uneasy about the notion of an overall anticipative systems theory design driving evolution, not about individual animals' responsiveness.

Javier Monserrat completely agreed with this, and said that Poli would in fact be in agreement too.

Carlos Castrodeza suggested there could be a terminological misunderstanding, where languages collide. Somebody in English words would mean 'responsiveness' and this is perhaps translated into Italian or Spanish as 'anticipation'. Anyway, he would defend the notion Spurway criticizes as 'anticipation' not in a metaphysical, ontological sense but considering the laws of physics. We have the Big Bang and with physical theories we can anticipate the evolution of the universe, in the sense that we can anticipate the elementary parts gathering into atoms, these into molecules, these into complex molecules, which then, at a certain point, are called 'life structures' and so on. In this sense perhaps we could naturalize the ontological concept of anticipation.

Javier Monserrat said that we should take this concept within its own limits. The same happens when we apply the term 'computation' to computational machines, but then some people begin to say that the universe is also a computational machine. We have to put the 'computation' notion in its own place.

Jens Degett wanted to add to the anticipation discussion, from a biologist's point of view. In his opinion, Roberto Poli wanted to emphasise that life has not occurred several times. Every single living cell or living organism has experienced the whole of evolution, and therefore they all have abilities to react to much more than the organism has seen in its own lifetime – it carries with it a lot of experience accumulated during the whole evolution throughout history.

Christine Heller wanted to underline the engineering side of what Poli had said: anticipatory mechanisms are models; engineers use models because when they design something they need to understand in advance what will be the outcome of it. The anticipatory aspect of reason is some kind of mental model that the human being needs to survive. And this has nothing to do with applying computational models to the human mind, there is just an inherent logic why our minds work like this.

Neil Spurway expressed absolute agreement with all this. His concern had been about a possible overarching metaphysical driving force to evolution, which he had sensed in the anticipation theory. But after the discussion he saw that he and Poli had in fact parallel ideas put in (hopefully illuminating) different ways.

Javier Monserrat said that, in connection with this idea of anticipation, the ideas of a very famous disciple of Lorenz, Rupert Riedl, about evolutionary knowledge theory, should not be forgotten. According to Riedl, the physical evolution (of an atom, molecule or a mineral) works because this purely physical entity embodies certain information about how the laws of the world function. In a certain sense all physical structural realities contain the information (though we cannot speak of consciousness) of how the world is. In this purely physical sense, they have a certain anticipation of the evolution of the world.

Javier Leach wanted to come back to the main problem with this idea of anticipation: that, in a certain aspect, it might not be adequate to be used in a scientific account. In his opinion it is necessary to know more clearly in which aspect this idea could impede real scientific research.

Neil Spurway approached this question, as a tentative first attempt, answering Riedl that it is very easy to wave hands and introduce some mysterious, mystical mechanism which by definition we cannot get sufficiently outside to understand, to manipulate or to reveal. It may not be necessary, but there is a major risk of that happening if we refer to notions of 'external planning' and 'driving forces'.

Natural selection and the prior processes producing the variations. Randomness vs. directedness

Javier Leach asked Spurway about something stated in his paper in page 14; the paragraph begins with: «Perhaps, however, my challenger did not strictly mean 'natural selection', but rather the prior processes producing the variations…». Can these processes be scientifically studied?

Neil Spurway said these are the kind of things that he had exemplified by Kauffman's self-organization and complexity theory, although several other people have also made proposals in this direction. They are all very interesting, but to see how they explicitly operate in terms of a scientifically describable mechanism is always the hard thing. The way Kaufmann's idea of a drive to complexity acted in biological systems was probably the least clear of all his examples and, as Spurway had commented the previous day, in his opinion it is clearer in some of the chemical systems and even the economic systems, to which he also applies his idea, than it is in biology. Spurway remains for the moment very interested in this kind of ideas, but himself tries to see how far we can go as a scientific description with the Darwinian notion that the mutations are entirely random. In the outcome an appearance of directedness can still result. It is perfectly possible to say this is simply due to the fact that those organisms which are more viable will survive, and then an overall picture is produced which, when looked back upon historically, has all the looks of something that was designed, following a purpose from the beginning, without it actually being necessary to say that such a purpose was built in as a driving force. A suspicion that a hint of a driving force was implied by the reference to 'anticipative systems' was what he had been worried about.

Carlos Castrodeza then said that, in his opinion, where Kauffman goes definitely wrong is when he says that on Darwinian terms the appearance of man is not to be anticipated, whereas Kauffman says that under his system it can be anticipated. And this would be where he is wrong, because random mutation is completely compatible with a loss of complexity. We can have a world where complexity is building itself constantly, but because of random mutations the outcome is not predictable.

Neil Spurway expressed his agreement.

Metaphysics in science and in the understanding of evolution

MIGUEL LORENTE first quoted something he had especially liked from page 13 of Spurway's paper presented the previous day: «I distrust the metaphysical entities of theology, but not of science. The reason for the difference is that the utility of the metaphysical concepts of science is subject to the most severe reality-checks countless times each day. Those… of metaphysical theology are exposed to ni such checks». Then he added that, without having to compare with theology, he wanted to stress the possibility of embodying metaphysics within science. Spurway had also differentiated between 'knowledge how' (more adapted to science, focused on explaining the reason, mechanism of reality) and 'knowledge that' (more related to the essence, the metaphysics of reality). But Lorente finds a problem with the metaphysics of evolution. Darwinian natural selection is supposed to work according to some rules, and it seems like Spurway had implied that there is some inside metaphysics in these selection rules. The idea of the existence of some finality has been necessarily assumed, because all the examples mentioned about evolution working on animals, human beings and reason are only explained by natural selection. In Lorente's opinion we have to introduce the finality of this selection in order to understand why this animal (or this man) is looking for some better adaptation in their existence. Therefore, in his opinion, an extra aspect of natural selection is needed, in the sense of some metaphysical cause.

NEIL SPURWAY said that, without being persuaded, he considered it an interesting comment, which perhaps could be rephrased by saying that as soon as we attempt to understand natural selection, we turn from merely observing what happens to seeking to have a concept of it, an understanding of it. But in so doing we will create what is described as a metaphysical model. That is a consequence of the way our minds work, we tend always to do this when we are explaining something, but that is in our minds not in the world. He then asked Lorente if he felt this description was correct or maybe just a misunderstanding of his prior words.

MIGUEL LORENTE replied that we understand metaphysics as being not only in our minds, but also in the real world. Therefore when we talk of some finality, this finality is not only in our minds but in each individual being following their convenience, completion or perfection. According to the traditional ontology this is a real reality inside the individual beings.

NEIL SPURWAY suggested the concept of force as an example of a metaphysical concept within science. We come up with the idea of force because of our experience of pressing against something. But what we observe in the physical world is never the force, it's always the consequence of what we call the force. We observe a body (with another metaphysical property – mass) accelerating, we make measurements of its position at different points in time, we find that it is moving at increasingly fast speeds as the time goes on and we say it's experiencing a force... But the observation is not of the force, the force is a concept which we add onto our observations to enable us to understand. This is an example of what Spurway thinks to be a general feature, that the metaphysical concept is in our minds, as an essential part of our means of understanding. We make a mental model of what is happening and in that model we use these concepts (of mass and force). But we do not observe the force or the mass, just what we believe to be their consequences. These ideas are simple pieces of metaphysics, but absolutely metaphysical, and are products of our way of understanding things. We have no fundamental basis for believing that there really is in the world an entity, a process which is what we label force: there are changes of position with time, that is all.

Miguel Lorente replied that this is all in physics, but not in metaphysics. In the observations we take only the experimental properties of bodies, like mass, motion... but then we can interpret these observations and properties of bodies as some kind of underlying causes or entities acting among themselves and we call them the entities and the causes that produce these other entities or these motions. Therefore this is another level of knowledge, there is the level of physical experience and the level of metaphysical causes, in his opinion.

Neil Spurway said that he and Lorente differ only as to whether this is knowledge of the external world. They agree that these concepts or mental models are essential to our understanding of the world.

Carlos Castrodeza then said he had been reminded of the big frustration Darwin had in his time, because many of his colleagues (mainly theologians) thought that he had discovered how God had created the natural world, and natural selection was just the instrument God used to implement evolution. One of the champions of the modern theory of evolution, Ronald A. Fischer, was a very committed Anglican. In his masterpiece «The Genetic Theory of Natural Selection» (1930) we find this sentence: «natural selection does not imply evolution», which of course is the argument used in Darwin's own times by his creationist colleagues. Then «The Biology of Ultimate Concern» (1967), an incredible book by Theodosius Dobzhansky, shows us in five chapters that Dobzhansky is as materialist and naturalist as anybody can be. But in the last chapter Dobzhansky wonders what gives meaning to all that and he actually finds that meaning in Teilhard de Chardin, whose thought is utterly remarkable. Then we have the last expression of Darwinism which, in Castrodeza's opinion, is «the physics of the selfish gene», and also the case of George R. Price (a scientist who generalized Darwin's thoughts and influenced tremendously in William Donald Hamilton and John Maynard Smith), who when he wrote with Smith a paper about «Hawks and Doves» objected to this title on theological grounds because the dove is the symbol of the Holy Spirit, so they finally changed the title to «Hawks and Mice». These little details all along the development of the theory of evolution show that there was always some metaphysics involved.

Clarifying Harald Walach's position and other applications of Quantum Mechanics

Javier Leach then reminded Monserrat that Walach's position still needed to be discussed.

Javier Monserrat said that Walach's presentation at the seminar had been actually very well received and that Walach himself had intended to exactly clarify the limits of his position. Walach does not agree with Penrose and does not have any theory about how quantum phenomena take place in the brain, he just considers several important concepts that play a role in Quantum Mechanics (QM) and are related to scientific observations in the physical world: complementarity principle, quantum coherence, quantum superposition, EPR effects, actions at a distance and so on. Walach's hypothesis is that in the psychological world we can also find some experiences which parallel these physical elements of QM. For instance, in the psychological world we observe some holistic experiences, which phenomenologically are also a fact. «Now», said Monserrat, «I can see you, Neil, and I think I am in a certain sense immersed in the space through the light, and I can sense you at a distance. I have this experience». He then added that a defender of constructionism would say this image is a neural structure in the brain, that it's not a real experience in the world. But other thinkers, such as American psychologist James Gibson, say we do have this kind of direct perception, which can be

phenomenologically described. In Monserrat's opinion Harald Walach was only trying to say that we can establish this parallel connection between the physical world and the psychological experience. Just like there is an 'entanglement' in the quantum physical world, we can also speak of 'entanglement' in the psychological experience. He did want to keep a distance from Penrose's theory and the like, emphasizing that this is a different thing from the QM's theories that try to explain the brain (which also need to be discussed and might be the subject for Sophia-Iberia's next seminar).

Neil Spurway accepted that he had previously misunderstood what was presented as Walach's position and appreciated the valuable clarification. He wanted also to comment about the experience mentioned by Monserrat of seeing him. Spurway does actually think that the image to which Monserrat is responding is in his (Monserrat's) brain. And of the essence of the EE approach is that these kinds of image have emerged, have survived and developed in minds because they work, because they are representations of the world, so they exemplify what Spurway has been arguing from the standpoint of EE. This particular mechanism has proved extremely fruitful, with immense survival value. That this is giving a very close approximation to reality is exactly the contention of EE, which attributes this achievement to natural selection. Many other possible ways of brain working could have existed, very probably *have* existed in the past, but they have not worked so well and haven't survived.

Javier Monserrat replied that assuming all the quantum effects (those considered by writers like Penrose, not Walach) are really taking place in our brains, then they would play a role in natural selection, and this could be interpreted from a Darwinian point of view. In fact, Stuart Kauffman has accepted this quantum approach to the understanding of the mind. It is a legitimate scientific position, although it still presents a lot of open questions and certainly does not yet offer a definitive scientific solution. The hypothesis is that quantum phenomena will perhaps help us explain the human and animal minds, and also the sensitivity in all living beings. The problem is how to explain the way in which these quantum phenomena take place in the brain and so far we haven't found a precise neurological explanation.

Christine Heller went back to talk about Walach's position in order to clarify that this speaker had specifically declared that he was not going to deal with the quantum effects in the brain itself, but was going to use QM just as a model to explain the relation between mind and body. He defines that these two aspects of the human being are complementary and therefore there is an 'entanglement' between them. Understanding Spurway's scepticism about the very weak activities of the neurons in the brain, Christine Heller underlined Walach's interesting use of the uncanny parallels between the quantum models and what we experience.

Javier Leach pointed out that language used in physics is different from language used in biology or neurosciences. In fact, in his opinion, the problem of reductionism is that we study different observations in biology than in physics, so we are required to interpret different things, but when we want to use the language of physics to explain our biological experiences then we may be subject to big mistakes. Therefore Leach asked the speaker how we can go from one science to another, because in his opinion that is a big problem.

Neil Spurway thought it was easier to reply to the last point first. Physiology (his actual profession) is a bridge discipline, which looks for physical and chemical mechanisms in our organism; it is a 'process biology', studying mechanical processes within physical systems that happen to be alive. Spurway is inclined to suspect that this kind of move towards more physical descriptions will go on as biology advances, in a process of understanding that involves linguistic breadth, not resulting in a reduction of our subjective

experience (in art, music, religion, emotion or science) but hopefully rather in an overall broadening of it. Then, in answer to Christine Heller's comment about Walach, the speaker accepted entirely that he had read into the summaries of what that speaker had said a purported mechanism that was not intended, so that there was no need for further dispute about it.

However, Spurway did see in Monserrat's later remarks a position closer to Roger Penrose than that of Harald Walach, that is to say, the possibility that quantum mechanisms may give some kind of explanation of consciousness. Without denying that this might be the case, Spurway again declared himself extremely doubtful, because the energies involved in quantum events are so many orders of magnitude below the energies involved in synaptic events that the amplification which would be necessary for a quantum event to influence a synaptic one would be immense. And as for Roger Penrose's actual model, which is to look for phenomena in the neural tubules rather than the synapses, neurophysiologists think he is looking in the wrong place. Our lecturer was not convinced that any of these models of quantum action are really helping the fundamental problem, because quantum events seem to have no more properties of consciousness than classical physical events. He wonders whether the Copenhagen Interpretation of Quantum Theory (not necessarily by Niels Bohr or Werner Heisenberg but by later generations) has lead unintentionally to this recruitment of Quantum Theory into attempts to understand consciousness, because their interpretation insisted on the role of the observer in the realization of a quantum event. But, strictly speaking, it is the instrument (which is not conscious) that is involved, not the observer. The association of ideas of the Copenhagen interpretation of QM with quantum phenomena in general may have been a very unfortunate one in leading people to imagine that somehow talking of quantum events is going to get us nearer to understanding consciousness than talking of classical physical events, when, actually, both have just the same kind of problems for that task. Consciousness is not part of our (quantum or classical) descriptions of a physical world; it is just not there, being rather 'the other side of the coin'. In Spurway's opinion, consciousness is absolutely the essence of life on this planet but it is not going to emerge from a physical description of any sort.

Javier Monserrat replied that from a scientific point of view there is very basic evidence: that we are living beings and all the characteristics of these living beings have been produced inside the world. We know that many millions of years ago in the universe there were only physical objects; at a certain stage in the evolution process of this physical world some entities were produced that we can describe as living beings. The basic hypothesis for how these new entities have been produced is that the physical world has a certain kind of organization that has made it possible. In Monserrat's opinion there is no alternative to this hypothesis. If we follow the process of evolution, probably the evolution of bacteria and unicellular beings during millions of years was a purely mechanical process. Then, the characteristic that we call 'sensation' was produced, marking its beginning in the history of the universe. We may also follow its evolution, a bio-physical evolution, so that we are able to describe the sensitive structure, the nervous system of many organisms along the zoological scale. All these animals have been produced from the physical world, the biological world being just a certain kind of organization of the physical world.

Then, at a certain point, in higher animals (such as amphibians and mammals), a psychological subject, able to respond to the environment, was also produced, and a certain global experience of the body emerged. This new experience of consciousness was produced, again, from the physical world. And taking into account our own human

consciousness, we have only one alternative, to find the physical support of our consciousness and our psychological experience. We need to find an explanation of this phenomenon. If we only refer to classical mechanics to explain this fact, we will end thinking that also the psychological world is pure determinism. And, for years, in many branches of science the principal philosophical-epistemological position has been reductionism, a position that makes it impossible to explain the experience of consciousness in humans and in higher animals. But besides the mechano-classical science (leading to reductionism) we now have this new science, QM, that has revealed a new world. The hypothesis could be very simple, such as the so called von Neumann-Stapp hypothesis, which has no relation with Penrose and is quite understandable. The problem is how to understand the way QM works in the brain. But if we follow a purely reductionist explanation of the world, in Monserrat's opinion, we have no way of explaining our psychical experience, ending in reductionism (humans being explained as robots) or dualism (rather usual among religious thinkers). For Javier Monserrat trying to explain the psychical experience with purely mechano-classical science is a bigger problem than trying to explain consciousness, self-experience and sensitivity from a QM point of view.

Neil Spurway decided to comment first upon Monserrat's important reference to determinism, because it's a very fundamental difference between the two outlooks. For Spurway, determinism is not a problem at all, being only the way that the outside observer describes what is going on, not the way that the individual whose mind is being talked about describes what is going on. The notion that our internal decisions could 'in principle' be predicted by an outside observer does not worry him. ('In principle' is stressed because in practice it could never happen, there could never be sufficient data available for a computer, however fast, actually to say with absolute certainty and in every instance what a person will decide). Because it would simply be the outside observer's description or the 'brain-story' description, of what to the person, the 'I-story', would seem (correctly) to be expressing not only his/her genetic make-up, personality and predispositions but also his/her experiences or life history, and making a rational computation of all this. But if the person were influenced by some random quantum event, absolutely beyond the possibility of the outside observer to predict, in Spurway's opinion, that would make him/her an irrational person, not a rational one. So, he contends that the idea of determinism being a terrible awful threat is a complete misunderstanding of the two view-points, the 'brain-story' vs. the 'I-story', (the outsider's vs. the insider's story), and this explains why he is much less tempted by quantum mechanisms than Monserrat is. Spurway is not only not eager to overcome determinism but also resistant to the notion that there could be unpredictable physical events underlying our mental processes.

Regarding Monserrat's notion that 'we otherwise have no chance of explaining consciousness', in fact Spurway doesn't think we will ever explain consciousness in that sense, nor fully understand matter either. We are part of this world, we are very small elements in this world, the notion that we are going utterly fundamentally to understand what we are made of, how we come to exist seems to him overreaching. In his opinion we can ever increasingly approach understanding of mechanisms and processes, but the underlying fundamental metaphysics will always elude us. And consciousness is no different in this respect from the matter out of which it has emerged. He then admitted that the two discussants have a very different fundamental viewpoint about this aspect of the debate.

Javier Monserrat thanked Professor Spurway for his profound thoughts and expressed everybody's appreciation for having had the chance to hear him and exchange ideas with him. At the time of closing the final session of the seminar, he explained that this seminar

had been designed for a small number of participants, but the real course of the seminar included not only the five sessions of presentations and open discussions but also what has been planned to take place thereafter. Summaries of all the sessions are being prepared, where many interesting ideas have been discussed, and then a final paper by each guest professor participating in the seminar (and also by some of the other participants) will be written after a certain reflection. With all these materials a publication will be prepared. Besides a few possibilities in Spain, Springer has also been contacted for this publication. Monserrat finally reminded professor Spurway and the audience that the central problem dealt with in this seminar is the evolutionary origin of reason, not the quantum problems. Then he expressed his desire to meet with Spurway again at the next ESSSAT Conference in Edinburgh (which will be organized by him).

NEIL SPURWAY also expressed his thanks for the session and the pleasure he would have to receive any of the audience members next April in Edinburgh.

Javier Monserrat then ended the session inviting all attendants to have dinner together to resume the interaction in a more pleasant environment.

V. JAVIER MONSERRAT'S POSTSESSION CONTRIBUTION

I agree with Neil Spurway in considering that an appropriate framework, though not the only one to address questions about the origin and nature of reason, is the school of Evolutionary Epistemology (EE). I agree also with his reference to the fundamental criterion necessary to explain why living beings are as they really are, both in their biological and psychological aspects, i.e., in their minds (the animal mind and the human mind). This criterion is, of course, the natural selection proposed by Darwin. There is a radical explanation able to find the causes of reason's emergence in humans and of the consolidation of its functions (functional nature). This cause is no doubt that genetic mutations, and accordingly learned behaviors (the same way as memes were transmitted in primitive cultures), have given their contribution to the survival of human species. Reason emerged and was evolutionarily consolidated because it was an effective instrument, an evolutionary advantage in the Darwinian sense.

It is clear that the criterion of «natural selection» can be qualified and clarified by other complementary concepts, usually proposed in the behavioral sciences and epistemology. So does in fact Spurway when it comes to exploratory behavior, learning by imitation, language, the process of trial and error, or Popperian conjectures and refutations. What is otherwise hidden behind certain conceptual schemes to explain animal and human behavior is always the criterion of Darwinian natural selection. Selection not only can be understood as «mechanical» (EEM), but also as «theoretical» (EET), as correctly points Spurway following ideas of Bradie (2004). It is now scientific evidence that certain mutations in molecular levels induced unexpected changes. These produced evolutionary advantages or disadvantages. The advantages were maintained by natural selection. But, both in animals and humans, some behavioral or theoretical successes (in humans) were advantageous and therefore, were imitated, transmitted (memetics,

traditio), without necessarily implying further molecular (mechanical) changes. The evolutionary advantages, therefore, occur not only by genetic mutations but also by advantageous changes in culture (either animal or human). Consequently there is not only natural selection in biology but also in culture.

However, besides these general propositions, we must enter the details provided by Spurway to explain, according to the criterion of «natural selection», what human reason is specifically and how it arises evolutionarily. He understands that the required theoretical framework is to recognize the prior existence of a certain knowledge that has emerged in animal species (each species has its own knowledge system). Knowledge is produced as a process of concepts' construction and, therefore, the question is how to move from concepts to reason. Let us remember Spurway's explanation in his presentation. «I have adhered to the customary language of EE in talking essentially about 'knowledge'. I have extended this seamlessly into 'concepts', believing that concepts constitute the ways in which we store knowledge. One task of the development stage I have now reached is to amplify this relationship. Then I must move from concepts to reason». But the question that arises is, of course, what are the concepts? There must be concepts appearing in the animal world, because what characterizes human species in the transition from animal to human (able to reason) is the emergence of new human concepts. Therefore, we are speaking about the transition from animal concepts (which were present in hominids) to the genesis of reason (human concepts).

Spurway added an important qualification. The transition from concepts to reason has been involved in the learning of skills (knowing how) and the learning of facts (knowing that). The emergence of 'learning that' was probably secondary, a derivation of 'learning how'. In Spurway's words: «Knowledge that, factual knowledge, was probably secondary, derivative from the 'how' knowledge. Of course, we cannot know how far back down the evolutionary tree (i.e. how much simpler in terms of neurological complexity) 'knowledge that' could meaningfully be distinguished. As a biologist I almost certainly envisage it as going further back in history, to simpler nervous systems, than most philosophers and theologians of earlier generations would have done, and many even now would probably do; but I think we might all agree that 'knowledge how' is primary, 'knowledge that' is derivative». What is 'knowing a fact' as different from 'knowing a skill'? Spurway's response is telling us that 'knowing that' is equivalent to knowing one concept. Let us go back again to his own words to be able to understand the terms accurately:

> «The 'that' knowledge of one of the world's regularities which each disposition implies is a feature which *we* perceive, but the protozoan does not and cannot. 'Knowledge that' is thus seen as the product of abstraction and generalization from 'knowledge how' – or, at least, from some forms of knowledge how. As such, I do not think it differs sharply from a *concept*. Of course, we tend to use the word 'concept' only at rather greater levels of generalization and abstraction, and at the extreme (in terms like 'the concept of mind', or 'the concept of time') this difference is very great, but at the lower

> end I can identify no sharp distinction. Indeed, I wonder whether *any* specific factual knowledge comes between the knowledge of how to swing among tree branches and the emergence of an incipient concept of spatial geometry».

Finally Spurway proposes a definition of reason related with the previous emergence of the concepts. Reason is for Spurway the ability to manipulate concepts, to the point that where there are concepts there is reason. «My claim», Spurway says, «is that reason is the capacity for handling concepts, so that where there are concepts there is reason». Reason, however, as Spurway nuances, is not sufficient to produce knowledge (and here we might recall the observations of Manuel Curado on the weaknesses of reason). But reason is necessary to formulate concepts, so that concepts and reason are so closely linked that it is almost impossible to determine the separation of the two, if you look back in evolution... «It should be clear, from everything I have said previously, that I do not accept that reason is *sufficient* for arriving at knowledge, let alone for formulating concepts – experience is essential too – but reason being *necessary* to their formulation is an appealing claim. For the purpose of the present paper, however, it doesn't matter if you disagree about that: we only need to agree that the propensities to acquire factual knowledge, to form concepts, and to reason about both, are all so closely intertwined that it seems impossible retrospectively to disentangle the evolution of any one from that of both the others».

Assuming what has been said above and agreeing with Spurway's thesis in the framework of Evolutionary Epistemology, we would like to make some observations to relate the criterion of Darwinian natural selection with the main theses maintained throughout the seminar. They consist, ultimately, in applying the criterion of natural selection to further questions open by Professor Spurway.

1) The first observation is that, to define scientifically what we want to explain, it is always necessary to start from a phenomenological description of the fact that we want to explain. We're talking about reason and therefore cannot circumvent the realization that reason is the human experience of mental activity that produces knowledge in a certain way (and of imaginative thinking). Part of the contributions to the seminar have described aspects of this rational psychic activity: for example, so far it is structures and systems analysis (Poli). I myself have insisted that the actual practice of knowledge production in science, as it is given in society, is also an objective phenomenological experience of reason. Reason comes to a human being who has already a body of deterministic biology (vg. DNA), but also a conscious mind (holistic field). Reason is phenomenologically a psycho-bio-physical product of the human entity. This is what we must explain according to the criterion of natural selection.

2) Let us try to reconstruct the evolutionary process in which natural selection has come to produce reason. It seems that life must have been born by the initial evolutionary advantage that led to the birth of the first cell. It was probably only a mechanical and deterministic system. DNA strands allowed reduplication and, therefore, cell reproduction produced random changes. Some were mechanical 'adaptive advantages'. The rigid stability of the mineral world

saw the birth of the 'evolutionary advantage' of the reproductive dynamics that allowed the growth towards improvement and perfection. Living beings gathered information (Lorenz, Riedl) and it is natural selection what stabilized the changes more suited to the environment.

3) However, an essential element of the phenomenology of reason, psyche or consciousness should have appeared initially in the evolutionary process. The Darwinian assumption is that the birth of «sensation» at a time of the evolutionary process led to an evolutionary advantage. It was a contribution to optimal survival, by allowing better information about the state of internal and external environment and more effective production of adaptive responses. It also founded new ingrained stimulus-response mechanisms which were built within information systems from primitive forms of sensation (obviously without psychic subject). Thus, evolution 'selected' the organisms with better sensory systems. So, complex sensory / perceptual systems were constructed by natural selection in each individual animal species. The evolutionary advantage of 'sensation' is part of the prehistory of reason.

4) Therefore, the evolutionary advantages that lead to reason are of two types and are biologically coordinated: the advantages of the deterministic mechanical system (originating from the DNA of the first cell) and the advantages of the sensory system. The better the mechanical system and the improved functional sensitive / perceptive design, the better appears a system of coordination between stimulus (sensation, information) and the mechanical responses (motor). Spurway means that both dimensions are present. The Darwinian advantages outlined in his presentation should not be viewed as purely mechanical (denying, or reducing to a pure epiphenomenic function, the world of sensation). Therefore, to talk of «adaptive advantages» in living beings as psycho-bio-physical entities (both in mechanical-deterministic and sensory-perceptual systems) requires taking a position on the physical nature of these evolutionarily acquired advantages. And this situation forces us to take a position on the theoretical frameworks that have been developed so far in physical sciences to understand what physical processes really are. These frameworks are two: the world of classical / Newtonian mechanics and the quantum world. They are not the same. The classical world describes a kind of deterministic causal interactions among the different classical objects. The quantum world, however, knows of the existence of a new type of causal interaction that has no existence in the classical world (coherence, superposition, quantum indetermination and action-at-a-distance or EPR effects). If we are not taking a scientifically defined position, we are talking about physical and mental processes as two parallel worlds that we do not know how to connect together, but we postulate their real interaction. I discussed this point further in my contribution to the fourth session of the seminar.

5) I recall that in the seminar's colloquium, following Spurway's presentation, there was discussion about the relevance of quantum neuroscience, particularly the assessment of the Hameroff-Penrose hypothesis. My personal position is to consider the Von Neumann-Stapp hypothesis to be the most obvious heuristic research horizon. Concerning the Hameroff-Penrose hypothesis I think it is a

powerful hypothesis which needs to be clarified and gives rise to different scientific assessments. It is legitimate to reject both the Hameroff-Penrose and the Von Neumann-Stapp hypotheses, but in that case one's position should be clarified. Then, scientific agnosticism may respond well to psycho-physical interactions (see fourth session). Reductionism also would consider that evolutionary changes, and any «selective advantage», should only pertain to the mechano-classic world. In any case one needs to argue how, from a classical neurology of simple deterministic interactions, the phenomenological properties of the psyche could be explained. This is what Edelman has tried to explain, with varying degrees of success, within his dynamic nucleus (core) theory. The birth in the brain of a mass of neural networks is an extraordinary evolutionary advantage because among the infinity of possible mappings (networks, patterns or engrams) only those engrams which are responding better to stimuli in real time are 'elected'. Thus, the brain, with its multiple entries and re-entries, constitutes an organ that makes possible a «neural Darwinism», which explains the human indetermination and flexibility of animal behavior.

6) The term concept, in epistemology or in ethology, has been applied to describing a psychological process in some way superior, that appears in a given time course. An amphibian, for example, has a sensory system and receives «signals» that trigger certain learned behaviors (with a neural program that allows it). The amphibian is a sensitive automata. But the amphibian does not build «concepts», it only sees «signals». That is still so in other higher species than that of amphibians. In contrast, in superior animals, with a more complex memory (probably because of the brain's developments in the temporal lobe, like we see in the initial connection brain in mammals) a new psychic function appears that justifies the use of the term «concept». A dog, for example when seeing its «master», updates in real time a series of records from the past in connection with its «master». The past is present (the *remembered present* of Edelman) and the animal acts not only in terms of the present but also of the past. The dog has a set of images of its master, updated by a «combining images» process based on neural networks of interconnected engrams. This «representative package» could be called a «concept» (an animal concept, of course). However, the mere use of concepts is not rational. It seems, in my view, we can't say that where there are concepts there is reason. The superior animals have concepts (representative packets of images) and yet, they have no reason. Notwithstanding we can acknowledge in animals a kind of proto-rational mental processes (e.g., certain logic functions, described by Lorenz and his school).

7) Therefore, in my opinion, if we talk about reason it is necessary that we refer to a specific psychological process that is born in the human species and that has made possible the human world. What is the difference between a human concept and an animal concept? This requires a more precise theory about the differences between the animal mind and the human mind (knowing, of course, that there are also many similarities, so much that the human mind derives evolutionarily from the animal mind). But, what happened in order to produce the hominization of the animal mind? What causes have produced the human

mind in its specific differences? In some ways this is again the problem posed by Spurway in terms of «knowing how» and «knowing that». What is the cause of the human glance over the objects themselves that forms a 'human concept'? We return here to the classical hominization theories in an evolutionary framework: A. Gehlen's non-specialization, the labor / theory of Luria (Marxism), the hominization by socialization / language (Thobias, Eccles, Leakey), or the continuity of the protohuman behaviors (Lorenz and Riedl). I have already mentioned in the fourth session, in my view, that the hyperformalization theory of Xavier Zubiri might be the most fundamental and relevant theory (being at the same time consistent with the other ones). The human concept began when the stimuli were «sensed» and «represented» as «reality» (as something objective, independent, that is there and whose constitution the rational mind is trying to closely represent). Being the human species in perception of things as «facts» it would have also understood that things are «real as structures». Understanding that the world is «real as a structure» would be the true origin of human reason.

8) Spurway refers to reason as the manipulation of concepts; the analysis and comparison of concepts leading to new concepts, therefore, which in some way are represented in the human mind. We believe that this description is essentially correct. But knowing what reason is requires a deeper explanation of the real nature of concepts. Above all, as we said before, it requires distinguishing between animal and human concepts in their specific nature. If we look at what was said in the previous point, for us the specifics of human concepts, and therefore of human manipulation of these concepts in the mind, would work with «representations of reality». This is reason or rationality. The concepts would consist of content systems that represent real structures. If this is so, then the analysis of concepts and their manipulation would be in essence analysis and synthesis of structures. It would be the same. Reason would be the analysis of elements, the connection and the reference to each other, the connective reference to other structures, always seeking to understand how the contents of reality structures or systems are stable. In this analysis of references, the last structure that human reason would be trying to represent would be the last dynamic consistency and stability of the universe. These are, indeed, the tasks of reason applied to producing knowledge in science: analysis of the facts, their description, their integration in the description of dynamic systems that constitute the universe and the anticipation of future established precisely by systems analysis (Poli). Moreover, reason, looking at the objective world (i.e., the empirical facts that should underpin the analytical and synthetic action of reason) would not only have experience of a mechano-classical world, fixed and stable objects that create a mechanical deterministic field; reason would also experience a holistic level of reality fields in which consciousness is immersed. Therefore, in order to 'know' reason would have to address these two areas of experience reported by Walach. Thus, a mechano-classical reason (manifested in classical physics) would be born, but also a quantum mechanical reason (underpinned by new holistic conceptions of reality).

9) If things were like this, it would be perfectly consistent with the hypothesis of «natural selection» in Darwinism. The genetic changes enabled the development of the brain with the growth of new bodies of neurons and made possible the perfection of sensory-motor areas and the development of brain connections. That would have the «advantage» of the evolutionary emergence of reason (EEM). Moreover, the exercise of reason in human groups created cultural transmission, memetic, cultural and effective habits and produced new cultures with increased rational capacity (EET). Our brains were capable to become rational by their morphology (EEM) and also learned to be rational in an open process in culture (EET). This was a process of natural selection and reason was undoubtedly a major selective factor in humans.

VI. CONCLUSION

The contribution of Professor Neil Spurway to the seminary has maintained the same spirit of the previous sessions and has been supported in the discussions. However, the debate raised in some specific discussions did not invalidate the agreement with the principles established, in general, by the Evolutionary Epistemology, whether understood as EEM or EET, depending on the explanation proposed by Spurway. The fundamental criterion proposed by this Professor in his presentation is Darwinian. Natural selection helps to explain why reason has emerged evolutionarily. Reason was born as a process of manipulation of concepts leading to the complexity of current knowledge. Reason, once emerged, has been a better survival factor and has been naturally selected as a feature of the human species.

In this regard, the Evolutionary Epistemology has traced the fundamental concepts that theoretically allow contextualizing why reason is born. Although this school has not been named explicitly in other sessions of the seminar, its evolutionary assumptions are the basis of the tenets of Poli, Walach, Manuel Curado, Mora and Cela Conde (maybe not Nickel). Basically, the evolutionary paradigm is a general consensus course of modern science and it has been on the basic seminar's tenets.

The comments of Javier Monserrat in his contribution to this session do insist again in views that have already been explained in previous sessions, but were applied now to evaluating the intervention of Spurway. They are not intended so much as a discussion of the basic theses of Spurway, but as a contribution of additional ideas which could lead us to go deeper into Spurway's proposals and at the same time to relate them to the sense of the previous sessions of the seminar.